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POWER SUPPLIES UNLIMITED

NJE CORPORATION Kenilworth, New Jersey

H# 510-539

INSTRUCTION MANUAL

CR LINE
SERIES REGULATED - SILICON CONTROLLED REFTIFIER
POWER SUPPLIES

SERIAL NUMBER 17823-8

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Rev B
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WARNING

THIS EQUIPMENT EMPLOYS VOLTAGES WHICH ARE DANGEROUS AND CAN BE FATAL IF CONTACTED BY OPERATING PERSONNEL. EXTREME CAUTION MUST BE EXERCISED WHEN WORKING WITH THIS EQUIPMENT.

INTRODUCTION

DEVIATIONS

This manual covers the Standard NJE power supplies as indicated in Section 1 herein. Where deviations to the specifications are built into equipment at customer's request, the nature of the deviation as it affects this manual is indicated in a Specification Sheet which precedes Section 1. If special schematic drawings, parts placement drawings and spare parts lists are required for the deviation they will be found in Section V of the manual, in place of the Standard material.

CORRESPONDENCE

All correspondence must reference the complete description of the unit as shown on the identification label located at the rear of the unit.

In requesting spare parts or information relative to parts, the Reference Designation, the rating, the description and the NJE Part Number must be specified for each part in question.

DESIGN IMPROVEMENTS

N.J.E. Corporation reserves the right to make design improvements on any instrument without prior notice.

REPRODUCTION

No material, drawings, text figures or any part of this instruction manual may be reproduced without express written consent of N. J. E. Corporation.

REPAIR SERVICE

N.J.E. Corporation provides complete repair facilities at the main plant and at local service centers as listed on the back of this manual. These repair facilities are adequately staffed with factory trained technicians to assure our customers of the most knowledgeable and expedient servicing of our equipment. All equipment forwarded to these facilities must be adequately packaged to prevent damage in transit.

OUT OF WARRANTY SERVICE:

Forward defective equipment to factory or local service center prepaid. A full description of difficulties encountered or the repair required should accompany this shipment. An estimate of the cost of repair will be submitted to you. The necessary servicing will be performed only upon receipt of your written service orders. Your equipment will be returned to you via collect shipment unless otherwise specified on your service order.

IN WARRANTY SERVICE:

If during the warranty period the power supply indicates an inherent defect, immediately communicate with your nearest NJE Field Representative in your area. If, after examination, he concurs that the unit is defective under the warranty conditions, he will provide written authorization for the return of the unit to the factory or the local field service center, whichever is nearest. N.J.E. Corporation will not assume any transportation charges on incoming equipment without the concurring written approval from its field representative.

801596

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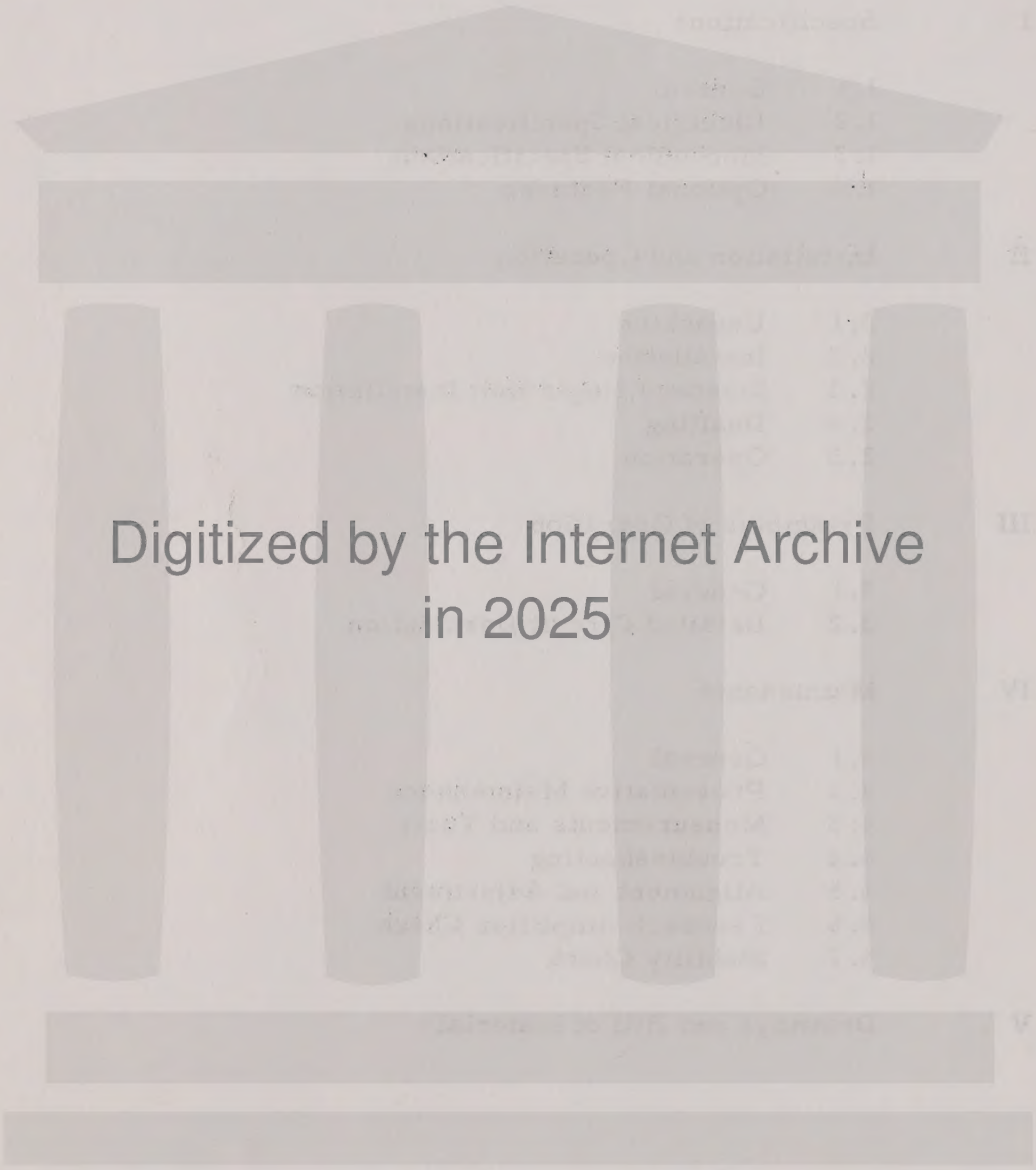

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SECTION I
SPECIFICATIONS

1.1 GENERAL:

The CR line of Silicon Controlled Rectifier, Series Regulated Power Supplies is designed for use in applications requiring a well regulated stable source of DC power at high values of current. The specifications herein are tabulated where ratings change from unit to unit (See Table 1-1) and are generalized into paragraphs where ratings are common.

1.2 GENERAL ELECTRICAL SPECIFICATIONS:

1.2.1 Input: See Table 1-1.

1.2.2 Output Voltage and Current: See Table 1-1.

1.2.3 Static Regulation:

1.2.3.1 Load: At constant input voltage, the regulation for load changes is less than 0.01% or 1 millivolt, whichever is greater, from half load to full load and less than 0.01% or 1 millivolt, whichever is greater, from half load to no load.

1.2.3.2 Line:

1.2.3.2.1 115 Volt Input Models: At constant load, the regulation is less than 0.02% or 1 millivolt, whichever is greater, for a line change from 115 Volts to 105 Volts, and less than 0.02% or 1 millivolt, whichever is greater, for a line change from 115 Volts to 125 Volts.

1.2.3.2.2 208 Volt Input Models: At constant load, the regulation is less than 0.02% or 1 millivolt, whichever is greater, for a line change from 208 Volts to plus 10% and less than 0.02% or 1 millivolt, whichever is greater, for a line change from 208 Volts to minus 10%

1.2.4 Ripple: 1 millivolt RMS, maximum.

1.2.5 Transient Response:

1.2.5.1 Load: For a no load to full load or a full load to no load prolonged step change, the output voltage will return to within 50 millivolts of the regulated region in less than 100 microseconds.

1.2.5.2 Line:

1.2.5.2.1 115 Volt Models: For a ±10 volt prolonged step change in line voltage, the output will remain in the regulated region.

1.2.5.2.2 208 Volt Models: For a ±10% prolonged step change in line voltage, the output voltage will remain in the regulated region.

1.2.6 Meters: Voltmeter and ammeter rated accurate to 2% of full scale value are provided on the front panel.

1.2.7 Polarity: The output may be "floated" up to 500V peak above ground. Either polarity may be grounded to chassis by means of terminals provided.

1.2.8 Duty: Continuous at ambient temperatures from 0°C to 45°C. Operation above 45°C is allowed provided the output current is derated linearly to zero at 80°C.

1.2.9 Remote Sensing: Sensing terminals, separate from the Output terminals, provide sensing and load regulation against the voltage at the load rather than the voltage at the power supply output terminals. This eliminates the otherwise unavoidable load regulation due to the voltage drop in the wires connecting the supply to the load. This feature does not eliminate voltage excursions resulting from load transients through load line impedance.

1.2.10 Remote Programming: The output voltage may be controlled accurately from a remote point if desired, by varying the resistance across the REMOTE PROGRAM terminals. The sensitivity of this circuit is approximately 140 ohms per volt above the minimum voltage within the voltage limits of Table 1-1.

1.2.11 Dualling: Two or more units may be operated in series to provide higher voltage output at rated current. Two like units may be operated in parallel provided that the total current drawn is derated by 10%. All dual unit installations must meet the cooling requirements of paragraph 1.3.2. The effectiveness of 3 or more units in parallel can be determined only by a test of the system.

1.2.12 Termination: A barrier type terminal strip at the rear of the unit provides interface connection for input, output, remote sensing, remote programming and ground, except that units with output current of 50 Amperes and above have the output termination by means of threaded studs. Those units which have front panel binding posts for out-

put termination in addition to the output terminals at the rear are so indicated in Table 1-1.

1.2.13 Protection: Variable electronic current limiting by front panel control adjusts maximum current over range from 5% to 105% of supply rating. Short circuit proof design is 100% factory tested. Protective fuse will interrupt input power in the event of internal failure.

1.2.14 Output Capacitor: The output capacitor is brought out to separate terminals at the rear of the unit. For normal operation, the factory set jumpers from the output capacitor to the respective output terminals should be left in place. Where improved transient response and dynamic characteristics are desired, the jumpers may be removed and an output capacitance connected directly at the remote load.

1.2.15 Constant Current: The current limiting feature makes the power supply essentially a constant current device. In this mode of operation the current regulation is better than 5% over the full voltage range of the supply. Improved current regulation can be achieved by sensing across an appropriate external resistor in series with the load. No internal modifications are required.

1.2.16 Resolution: Continuously variable ten turn Output Adjust potentiometer provides the resolution indicated in Table 1-1.

1.3 MECHANICAL SPECIFICATIONS:

1.3.1 Outline Drawing: Table 1-1 indicates which Outline Drawing is applicable to the unit in question.

1.3.2 Airflow: Units of panel height of 3 1/2" do not have blowers and depend on conduction and convection for cooling. Units of panel height 5-1/4" and greater have internal blowers and depend on forced air cooling in addition to the conduction and convection cooling. Air flow paths as indicated in the appropriate Outline drawing must not be blocked. Where two or more units are rack-mounted one above the other or where adjacent equipment increases the ambient temperature above the limits specified in paragraph 1.2.8 above, filler panels of at least 1-3/4" height should be installed above and below the power supplies in question.

1.3.3 Mounting: When installed in racks, it is recommended that support angles be provided so that the power supply weight is not supported entirely by the front panel mounting hardware.

1.3.4 Finish: Front Panel finished in dark grey enamel equivalent to FED STD 595 chip #26132 Panel marking is white. All other finishes are appropriate paint, plating or chemical film as required.

1.4 OPTIONAL FEATURES:

Table 1-2 indicates the specific optional features which are available on any given unit. The general description of these optional features follows:

1.4.1 Suffix (-50): Extension of the Input voltage frequency range to 47-65 cps. This option requires that the output current be derated by 1/6 of the maximum rating as specified in Table 1-1.

1.4.2 Suffix (-B): Addition of bench adapters.

1.4.3 Suffix (-P): Addition of three wire power cord and plug.

1.4.4 Suffix (-SF): Non-standard finish to front panel of unit.

1.4.4.1 Where specifying (-SF) option customer must provide NJE the following information:

Color to be used (preferrably FED STD 595 chip number).

Color to be used for marking.

Process to be used if other than NJE Standard finish process

Whether paint is to be supplied by customer or NJE.

1.4.5 Suffix (-LV) and/or (-LC): Output Adjust (-LV) or Current Control (-LC) potentiometer and knob replaced by a single turn screwdriver adjust potentiometer with shaftlock. (-LV) option changes Output Adjust resolution to 1%.

NOTE: Ten-turn controls with decade dials have built-in locks.

1.4.6 Prefix (E): Deletion of meters and replacement of 10 turn output adjust potentiometer by coarse and fine single turn potentiometers on concentric shafts. This changes resolution to 0.05%.

1.4.7 Suffix (-220): Conversion of unit with nominal input voltage of 208 volts to nominal of 220 volts.

1.3.4 Finish: Front Panel finished in dark grey enamel equivalent to FED STD 595 chip #26132 Panel marking is white. All other finishes are appropriate paint, plating or chemical film as required.

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1.4.5 Suffix (-LV) and/or (-LC): Output Adjust (-LV) or Current Control (-LC) potentiometer and knob replaced by a single turn screwdriver adjust potentiometer with shaftlock. (-LV) option changes Output Adjust resolution to 1%.

NOTE: Ten-turn controls with decade dials have built-in locks.

1.4.6 Prefix (E): Deletion of meters and replacement of 10 turn output adjust potentiometer by coarse and fine single turn potentiometers on concentric shafts. This changes resolution to 0.05%.

1.4.7 Suffix (-220): Conversion of unit with nominal input voltage of 208 volts to nominal of 220 volts.

NOTE: Example of buildup of final model number for a CR-36-15 without meters and with bench adapter and line cord is as follows: ECR-36-15-B-P

NOTE: NJE Corporation invites requests for quotations on special requirements which can be accomplished by deviations of standard catalogue units.

801685

MODEL NO.	OUTPUT		INPUT				PRELOAD (1)		FRONT PANEL OUTPUT	RESOLUTION	WEIGHT		OUTLINE DWG.
	VOLTS	AMPS	VOLTS	Ø	FREQ	AMPS	I	ΔE			NET	SHIP	
CR-18-30	0-18	0-30	105-125	1	55-65	15	1.5	0-3	NO	3MV	80	105	303304-303305
CR-36-8	0-36	0-8	105-125	1	55-65	6	NONE	—	YES	5MV	40	65	303285-303290
CR-36-15	0-36	0-15	105-125	1	55-65	11	NONE	—	YES	5MV	55	90	303317-303314
CR-36-20	0-36	0-20	105-125	1	55-65	15	1.0	0-6	NO	5MV	80	105	303304-303305
CR-36-30	0-36	0-30	105-125	1	55-65	20	1.5	0-3	YES	5MV	90	135	303386-303385
CR-36-50	0-36	0-50	208 $^{+10\%}$	1	55-65	20	3.0	0-6	NO	5MV	200	240	303380-303381 303382-303383
CR-60-9	0-60	0-9	105-125	1	55-65	11	NONE	—	YES	7MV	55	90	303317-303314
CR-60-18	0-60	0-18	105-125	1	55-65	20	1.0	0-6	YES	7MV	90	135	303385-303386

(1) PRELOAD CURRENT(I) REQUIRED BETWEEN SPECIFIED VOLTAGE(ΔE).

TABLE 1-1

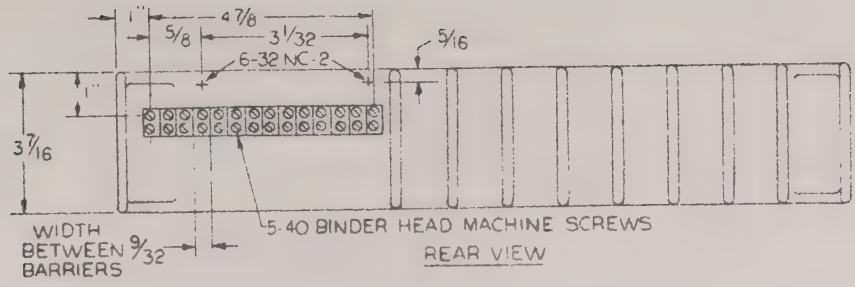
TABULATED SPECIFICATIONS

MODEL NO.	OPTION							
	(-50)	(-B)	(-P)	(-SF)	(-LV)	(-LC)	(-220)	(E)
CR-18-30	X	X		X	X	X		X
CR-36-8	X	X	X	X	X	X		X
CR-36-15	X	X	X	X	X	X		X
CR-36-20	X	X		X	X	X		X
CR-36-30	X	X		X	X	X		X
CR-36-50	X			X	X	X	X	X
CR-60-9	X	X	X	X	X	X		X
CR-60-18	X	X		X	X	X		X

X MEANS OPTION AVAILABLE

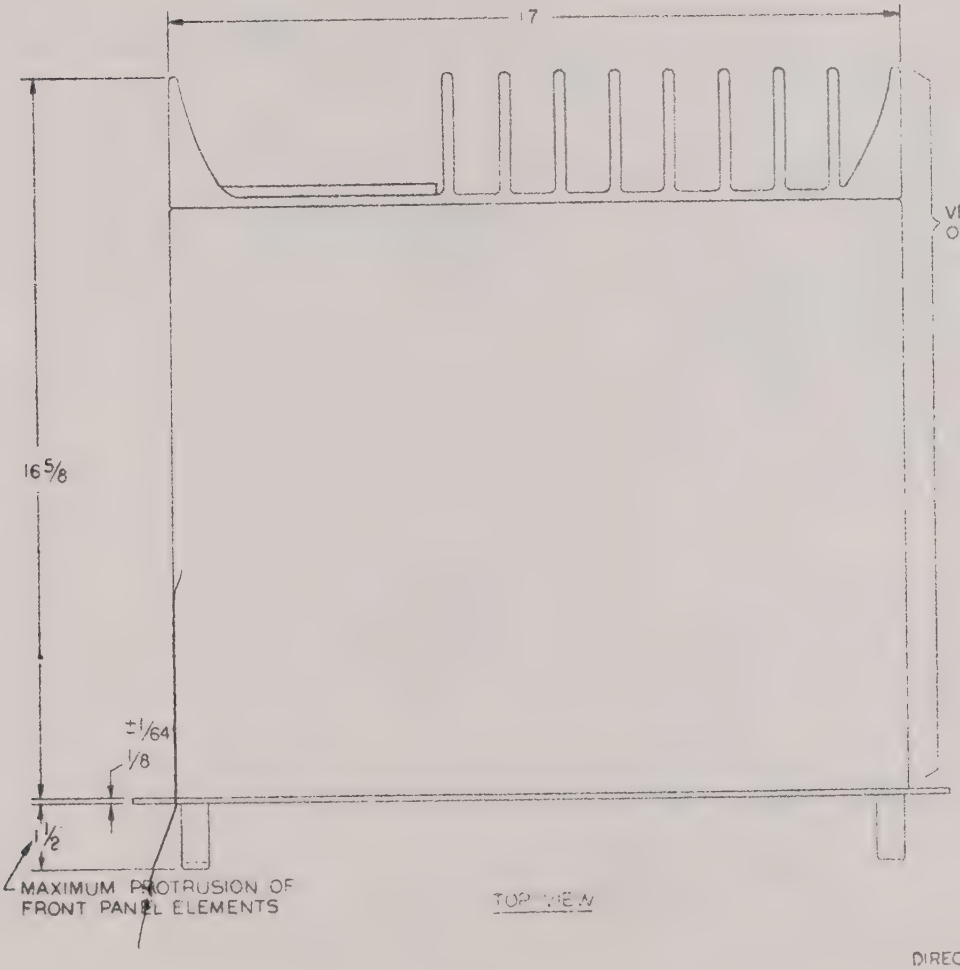
TABLE 1-2

OPTION LIST

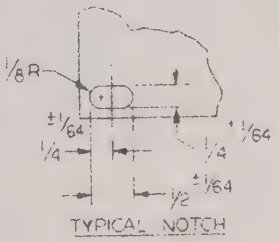


REAR VIEW

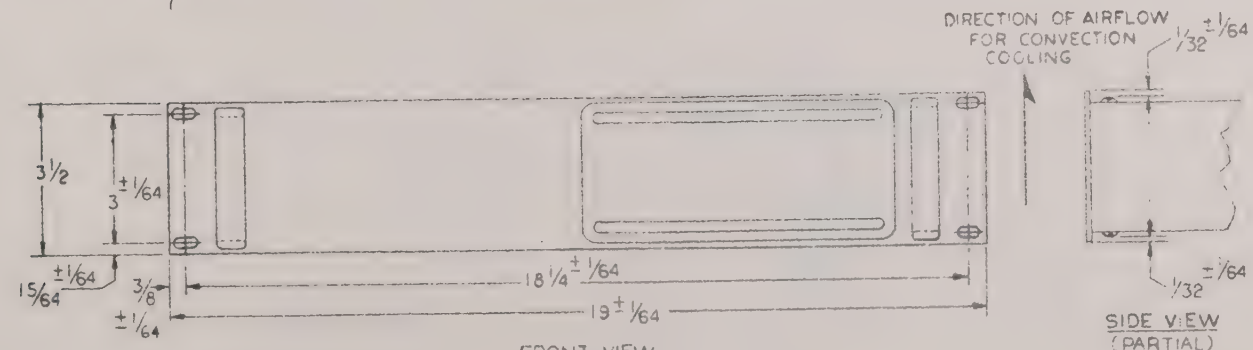
NOTE:
1. ALL TOLERANCES ±1/32 UNLESS OTHERWISE SPECIFIED



TOP VIEW



TYPICAL NOTCH

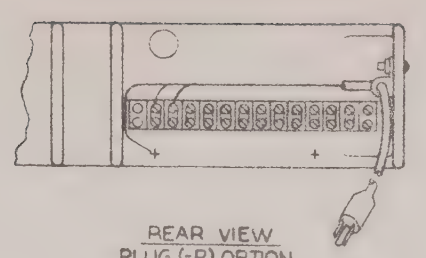


FRONT VIEW

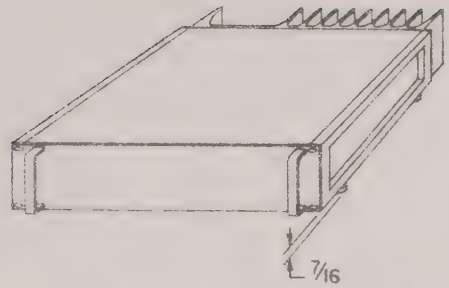
SIDE VIEW (PARTIAL)

OUTLINE DRAWING

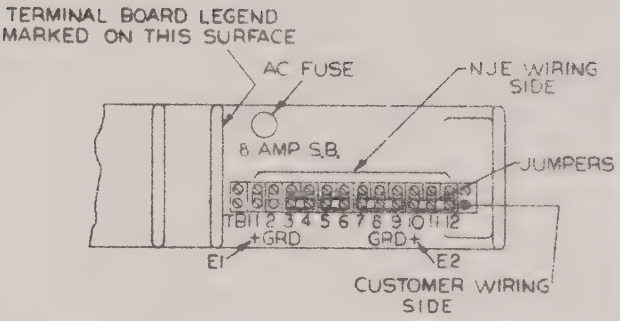
3½" PANEL SERIES



REAR VIEW
PLUG (-P) OPTION



BENCH ADAPTER (-B) OPTION

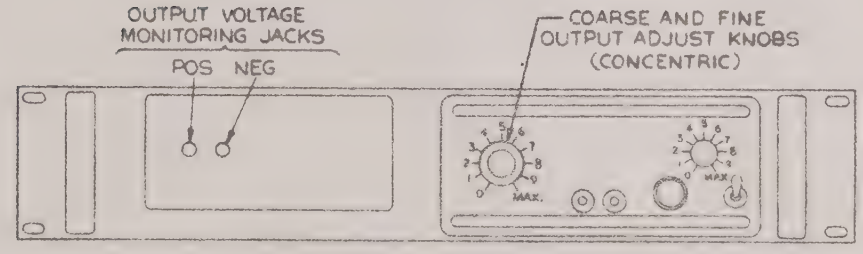


REAR VIEW
REAR ELEMENTS

TB1 TERMINAL BOARD LEGEND				
TERM NO	SCREENED FUNCTION	RECOM'D WIRE SIZE	REMARKS	
1	AC	NO. 18 AWG	HIGH SIDE OF AC INPUT	
2	AC	NO.18 AWG	RETURN SIDE OF AC INPUT	
3 4	REMOTE PROGRAM	NO.20 AWG SHIELD. PR	NORMALLY JUMPED TOGETHER	1
5 6	DUALLING	NO.20 AWG SHIELDED	NORMALLY JUMPED TOGETHER	2
7	POS SEN	NO.20 AWG	NORMALLY JUMPED TO POS OUT	1
8	POS OUT	NO.16 AWG		
9	POS CAP	NO.16 AWG	NORMALLY JUMPED TO POS OUT	
10	NEG CAP	NO.16 AWG	NORMALLY JUMPED TO NEG OUT	
11	NEG OUT	NO.16 AWG		
12	NEG SEN	NO.20 AWG	NORMALLY JUMPED TO NEG OUT	1

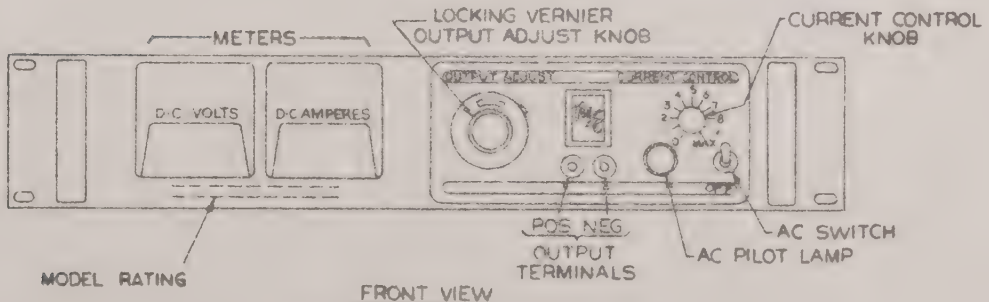
E1	GRD	NO. 18 AWG	AC GROUND
E2	GRD	NO. 16 AWG	DC GROUND

1-SHIELDED PAIR WHERE USED
2-TERM. NO 5 IS DUALLING DRIVE POINT



FRONT VIEW

NON-METERED FRONT PANEL ELEMENTS
OPTION (E-)



FRONT VIEW

FRONT PANEL ELEMENTS

CR LINE
3½" PANEL SERIES

SECTION II

INSTALLATION AND OPERATION

2.1 UNPACKING. The power supply is shipped in a corrugated carton which is floated on sufficient insulation in a heavy-duty shipping carton. Aside from normal precaution against damage to the unit in opening the cartons and removing the unit, no special procedures are required. The carton should be opened immediately upon receipt and the contents inspected for shipping damage. The Power Supply was checked electrically and mechanically before it left the factory, and is warranted to be in perfect operating condition. This warranty does not cover possible damage incurred during shipment. Therefore, any evidence of mishandling, such as broken, deformed or missing parts, should be brought to the attention of the transportation company and a claim should be entered. Remove top cover plate and inspect all components and wiring, both on the chassis and panel, as well as the mechanical condition of the housing. The literature packed with the supply should be removed and held for reference in operating the equipment.

2.2 INSTALLATION: Refer to Table 1-1. which indicates which Outline Drawing is to be followed for the model in question. This Outline Drawing shows mounting dimensions, air flow requirements, interface wiring information and other data pertinent to proper installation. Careful observance of All the specification requirements in Section 1 is essential to a proper installation. READ THE SPECIFICATIONS CAREFULLY BEFORE PROCEEDING.

When the unit has been properly placed in position or mounted in its rack and secured in place by the panel screws, electrical connections should be made in accordance with the following step-by-step procedure. Wire sizes to be used and the terminal locations are specified on the appropriate Outline Drawing of Section 1-3. Terminal functions listed in the following instructions are clearly screened on the equipment itself, as well as being indicated on both the outline of Section 1-3 and the schematic drawing of Section 5.

2.3 STANDARD SINGLE UNIT ELECTRICAL INSTALLATION.

2.3.1 Output Grounding: Connect either the positive (POS OUT) or negative (NEG OUT) DC output terminal of the supply (depending upon desired output polarity) directly to the chassis ground terminal (GRD) at the barrier strip on the rear of the chassis, and connect the ground terminal to the system ground.

NOTE: If it is necessary that the power supply circuit float above or below ground, it is recommended that the output terminal should be connected to the chassis ground terminal by a 0.1 microfarad 600 VDC capacitor in place of the direct connection. Use of this by-pass capacitor will improve the stability of the circuit in the ungrounded condition, and reduce the effect of external interference and hum. Refer to Polarity Specification in Section 1 for maximum limitation on floating voltage permitted.

2.3.2 Output Connection: Connect the positive and negative output terminals (POS OUT) and (NEG OUT), respectively to the corresponding terminals of the external load. Use heavier gauge wire than that specified if long distances to the load are involved.

2.3.3 REMOTE SENSING: All units are shipped from the factory with the REMOTE SENSING feature jumpered out on the inter-connection terminal board as follows: (POS SENS) connected to (POS OUT) and (NEG SENS) connected to (NEG OUT). With this connection, the regulation specifications are met ONLY at the output terminals of the supply. If it is desired to have accurate regulation at the remote load point, rather than at the output terminals, proceed as follows:

Connect the output terminals to the load per Paragraph 2.3.2 above. Remove the Jumpers from (POS SENS) to (POS OUT) and (NEG SENS) to (NEG OUT) respectively. Observing correct polarity, run a twisted pair of No. 20 AWG wire (or larger) from (POS SENS) to the positive load point and from (NEG SENS) to the negative load point.

WARNING: DO NOT OPERATE POWER SUPPLY WITHOUT THE SENSING LEADS CONNECTED EITHER REMOTELY OR LOCALLY. MOST CUSTOMER COMPLAINTS OF POOR OPERATION ARE DUE TO IMPROPER SENSING LEAD CONNECTION.

WHEN THE POINT OF REMOTE SENSING IS MORE THAN 10 FEET FROM THE POWER SUPPLY, OSCILLATIONS MAY DEVELOP. A POSSIBLE CURE IS TO CONNECT REMOTE CAPACITANCE AS DESCRIBED IN PARAGRAPH 2.3.4 AND AS CLOSE TO THE POINT OF SENSING AS IS PHYSICALLY POSSIBLE.

2.3.4 Output Capacitor Connections: This feature is not provided on all units. When included in the equipment, the terminals are listed as (POS CAP) and (NEG CAP) on the Outline Drawing. The power supply has been shipped from the factory with the appropriate filter capacitors connected to the appropriate output terminals at the interconnection terminal board, This arrangement is satisfactory for most applications. However, if better transient and dynamic characteristics are required, further improvement can be effected by using an independent capacitor mounted as close to the ultimate load as is practical.

The capacitor used should have the same voltage rating of the power supply output capacitance (see the schematic drawing for the rating of the capacitor connected to the Pos Cap and Neg Cap terminals) and at least the same capacitance rating should be used. Additional capacitors may be ordered by specifying the NJE Part Number of the output capacitor from the Spare Parts List of Section 5.

Reconnections are made as follows: Remove the jumper connection provided between (Pos Out) and (Pos Cap) and between (Neg Out) and (Neg Cap). The load leads should be connected as in paragraph 2.3.2 above. Connect the new capacitor directly at the load being careful to observe polarity. In order to make this connection effective, it will be necessary to utilize the Remote Sensing Connections described in paragraph 2.3.3 above.

2.3.5 REMOTE PROGRAM: To utilize the Remote Programming feature of the unit, remove the jumper across the REMOTE PROGRAM terminals and connect a resistor across the REMOTE PROGRAM terminals. If the resistor is to be located remotely from the power supply, a pair of No. 20 AWG twisted wires should be used. The resistance (R) of the remote program resistor may be calculated as follows:

$$R = (\Omega/V) \quad (V_o - V \text{ min}) \text{ ohms}$$

Where (R) is the desired resistance, (Ω/V) is the Remote Programming sensitivity from Section 1. (V_o) is the desired output voltage and (V_{min}) is the minimum voltage allowed for the power supply as specified in Section 1.

When using this connection the OUTPUT ADJUST potentiometer should be set to zero (extreme counter clockwise position).

WARNING: DO NOT OPERATE THE POWER SUPPLY WITH THE "REMOTE PROGRAM" TERMINALS OPEN CIRCUITED.

2.3.6 INPUT CONNECTION:

2.3.6.1 Single Phase Units: Referring to the correct Outline Drawing as indicated by Table 1-1, connect the proper wire size specified to the two AC terminals, observing the "high" and "return" leads must be wired to the correct terminals. The system ground is connected to the GRD terminals associated with the AC input terminals.

2.3.6.2 Three Phase Units: All units which are specified in Table 1-1 as "208 volts, three phase", are intended to be used with a four wire system with the neutral connected. The Outline Drawing indicated in Table 1-1 indicates the correct wire sizes to be used in wiring to the Phase A, Phase B, Phase C and Neutral terminals. In addition, the system ground must be connected to the GRD terminal associated with the AC input terminals. For those units where Table 1-1 specifies input of 460 volts three phase or 220 volts 3 phase 3 wire, the system is a three wire system with no neutral. The connection is similar to that of the four wire system except that no neutral lead is required.

2.3.7 CONSTANT CURRENT CONNECTION: Where specified in Section 1, some NJE Power Supplies may be converted to Constant Current Regulated supplies. Figure 2-1 provides information for making this reconnection. Since there are numerous possibilities and parameters which must be considered, the information provided must of necessity be limited. For special applications, consult the factory Application Engineering Department.

On those units equipped with variable current limiting overload protection (See Section I), and where regulation requirements are restricted, Constant Current applications may be achieved directly without resorting to the more refined connection of Figure 2-1. This method of operation is described in Section 2-5.

2.4 DUALLING:

2.4.1 COOLING OF DUAL UNIT INSTALLATION: Where the dual units are to be rack mounted one directly above the other, the filler panels referred to in Air Flow specification per paragraph 1.3.2 must be used. These panels may be ordered from NJE Corporation if the same finish is desired. For standard finish, 1-3/4 by 19" filler panels, order NJE Part Number 22164.

2.4.2 SERIES CONNECTION: Those NJE Power Supplies which may be connected in series, as indicated by the Dualling specification in Section 1 can be so connected using Figure 2-2A. If "S" option is required, the unit should be ordered specifying the "S" option. Where field connection is required, reverse voltage protection diodes must be installed to protect against reverse voltage during a short circuit on the series connected supplies.

These diodes should have a Forward Average Current rating equal or greater than the output current rating of the supply and a Peak Inverse Voltage rating greater than the highest operating voltage of the application. The diodes must be connected in the nonconducting direction across the power supply output terminals. The series connection is quite straight forward and is essentially the same as connecting two batteries in series. Each supply is independently controlled and delivers an output voltage within its own capability. The total output voltage is, of course, the sum of that of the two supplies.

Connection of the series option, including the location of the reverse voltage protection diodes, is clearly shown in Figure 2-2A. The connection of the sensing leads is for the remote sensing mode of operation. If precise regulation at the load is not required, the sensing leads may be left jumpered at the respective output terminals as in Paragraph 2.3.3.

2.4.3 PARALLEL CONNECTION: Those NJE Power Supplies which may be connected in parallel, as indicated by the Dualling Specification in Section 1, can be connected in parallel using Figure 2-2B. The total paralleled current must be derated by 10% from the individual current rating as the two supplies cannot be made to divide the load exactly.

2.5 OPERATION:

2.5.1 The following check list should be followed before making the unit operational:

2.5.1.1 AC power switch in the OFF position.
2.5.1.2 VOLTAGE ADJUST potentiometer in the extreme counter clockwise position.
2.5.1.3 CURRENT CONTROL potentiometer (where provided) in the extreme clockwise position.
2.5.1.4 Input wiring made per Paragraph 2.3.6
2.5.1.5 Output Grounding wired per Paragraph 2.3.1
2.5.1.6 Output Wiring made per Paragraph 2.3.2
2.5.1.7 Remote Sensing wiring made per Paragraph 2.3.3
2.5.1.8 Output Capacitor wiring (where provided) made per Paragraph 2.3.4
2.5.1.9 Remote Programming wiring made per Paragraph 2.3.5
2.5.1.10 Constant Current wiring (where provided) made per paragraph 2.3.7.

2.5.1.11 Dualling connection (where desired) made per paragraph 2.4

2.5.2 Step by step operation based on the location of controls as indicated on the Outline Drawing specified in Table 1-1:

2.5.2.1 Energize the AC line

2.5.2.2 Operate the AC power switch to the On Position. The pilot lamp should lite.

2.5.2.3 While monitoring both output voltage and current, slowly rotate the VOLTAGE ADJUST potentiometer clockwise until the desired voltage level is reached.

2.5.2.3.1 If the desired voltage and/or current level (within the ratings of the unit) cannot be reached, de-energize the AC line and recheck all connections per paragraph 2.5.1 above. If still unable to achieve the desired levels, refer to the Trouble Shooting section at the rear of the Manual.

2.5.2.4 CURRENT CONTROL (where provided) may be set to the desired level as follows:

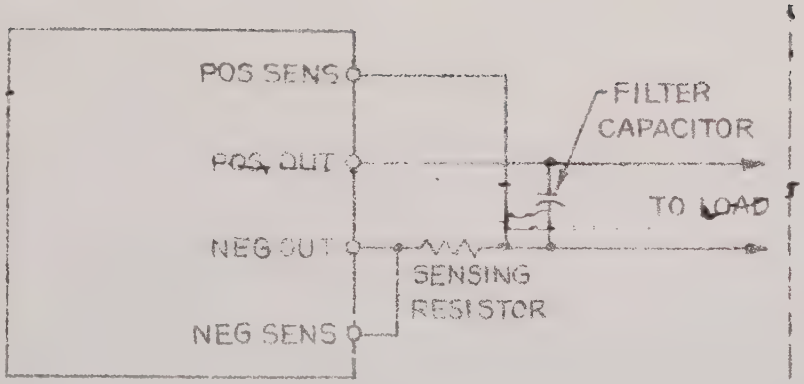
2.5.2.4.1 Method #1: While monitoring the load current, apply a short circuit across the load and rotate the CURRENT CONTROL potentiometer counter clockwise until the desired current level is reached.

2.5.2.4.2 Method #2: While monitoring the load voltage and current, adjust the load so that the desired levels are reached. Rotate the CURRENT CONTROL potentiometer slowly counter clockwise until the current level begins to fall off. A slight clockwise turn of the CURRENT CONTROL will then set the current limiting action just above the Operating level.

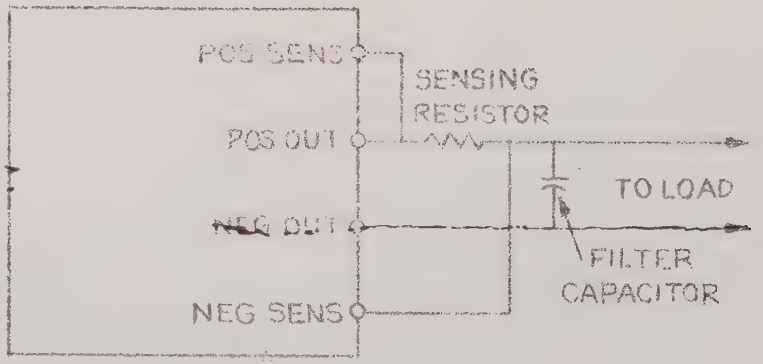
2.5.2.4.3 Method #3: Leaving the CURRENT CONTROL at the extreme clockwise position sets the current limiting action at approximately 110% of the maximum current rating of the supply.

NOTE 1: The current limiting feature is essentially a constant current device. As the load resistance is reduced toward an eventual short circuit condition, the load current will be limited to the preset CURRENT CONTROL setting, and it will hold at this value as the output voltage falls toward zero. The current regulation is better than 5% as the load resistance varies to cause a full swing of output voltage and is proportionally better for smaller load resistance changes.

NOTE 2: For the RVC and the RB Lines, which are provided with both voltage and current regulation with automatic crossover circuitry, the current limiting characteristic described above is highly regulated. Actual current regulation parameters are in accordance with the specifications noted in Section 1.



ALL UNITS EXCEPT TC LINE



TC LINE ONLY

PROCEDURE

1. SENSING RESISTOR SHOULD BE SELECTED TO PRODUCE APPROXIMATELY 1 VOLT DROP AT MAXIMUM DESIRED CONSTANT CURRENT. RESISTOR WATTAGE SHOULD BE AT LEAST FOUR TIMES MAXIMUM DISSIPATION FOR CURRENT STABILITY. SEE NOTE 4.
2. FILTER CAPACITOR SHOULD BE 6 - 10 MICROFARADS, OIL OR TANTALYTIC, WITH VOLTAGE RATING GREATER THAN MAXIMUM DESIRED OUTPUT VOLTAGE.

NOTE 1: SEE OUTLINE DRAWING, SECTION I, FOR TERMINAL CONNECTIONS AND WIRE SIZES.

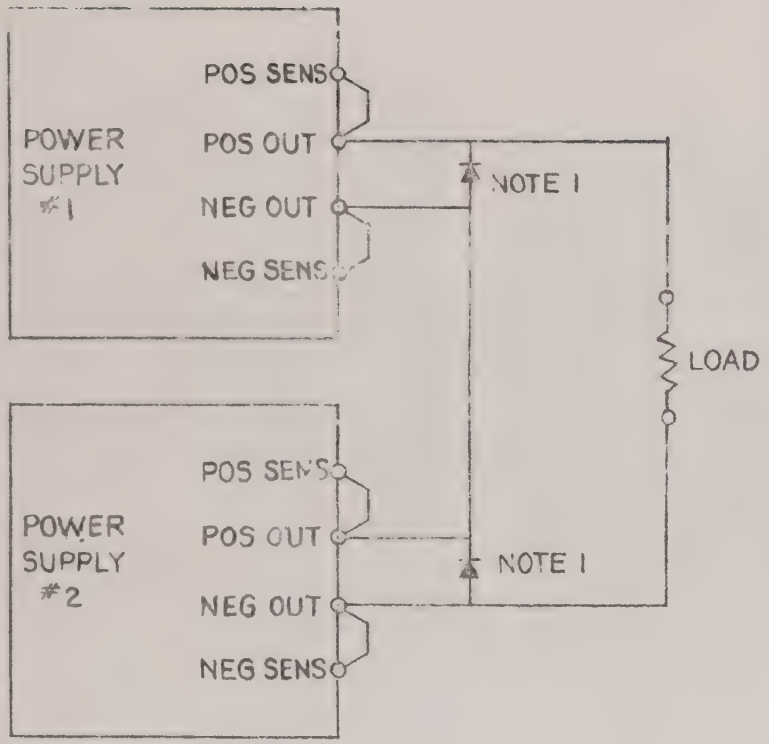
NOTE 2: ON TC UNITS, AN INTERNAL JUMPER BETWEEN TERMINALS 6 AND 11 ON PRINTED CIRCUIT BOARD A2 (96PC) MUST BE ADDED FOR CONSTANT CURRENT OPERATION.

NOTE 3: A POTENTIOMETER APPROXIMATELY 10% OF THE RESISTANCE OF THE OUTPUT ADJUST POTENTIOMETER SHOULD BE INSERTED IN THE PROGRAMMING TERMINALS. THE OUTPUT ADJUST SHOULD BE SET TO ITS MINIMUM POSITION. THE NEW POTENTIOMETER WILL THEN PROVIDE CURRENT CONTROL OVER THE DESIRED RANGE. IF DESIRED, THE OUTPUT ADJUST ITSELF MAY BE USED FOR CURRENT CONTROL, BUT ONLY THE LOWEST PORTION OF THE POTENTIOMETER IS USED. IF AVAILABLE ON THE SUPPLY, THE FINE CONTROL CAN PROVIDE ADEQUATE RESOLUTION.

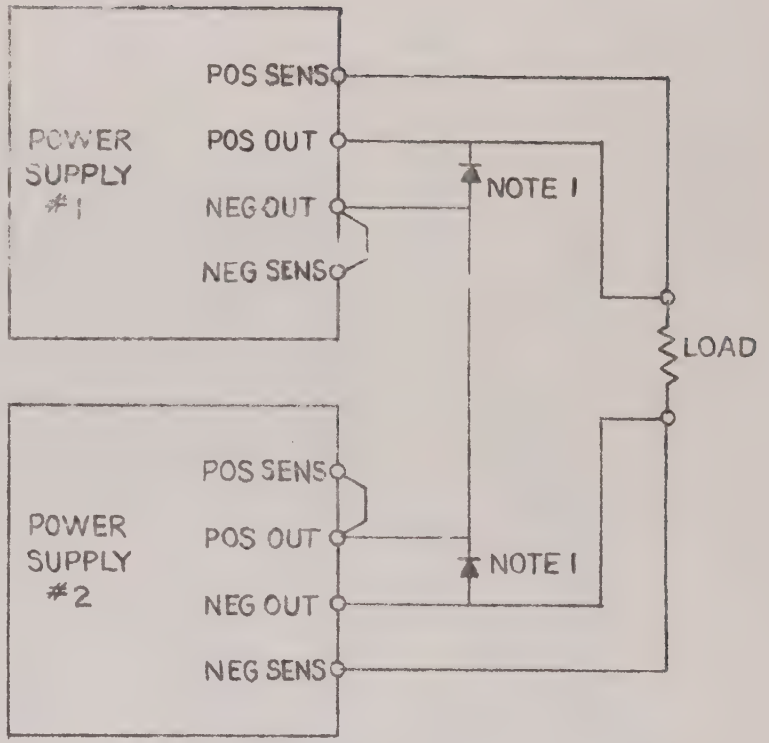
NOTE 4: LOW TEMPERATURE COEFFICIENT RESISTORS WILL IMPROVE STABILITY.

CONSTANT CURRENT CONNECTION

FIG. 2 1



LOCAL SENSING

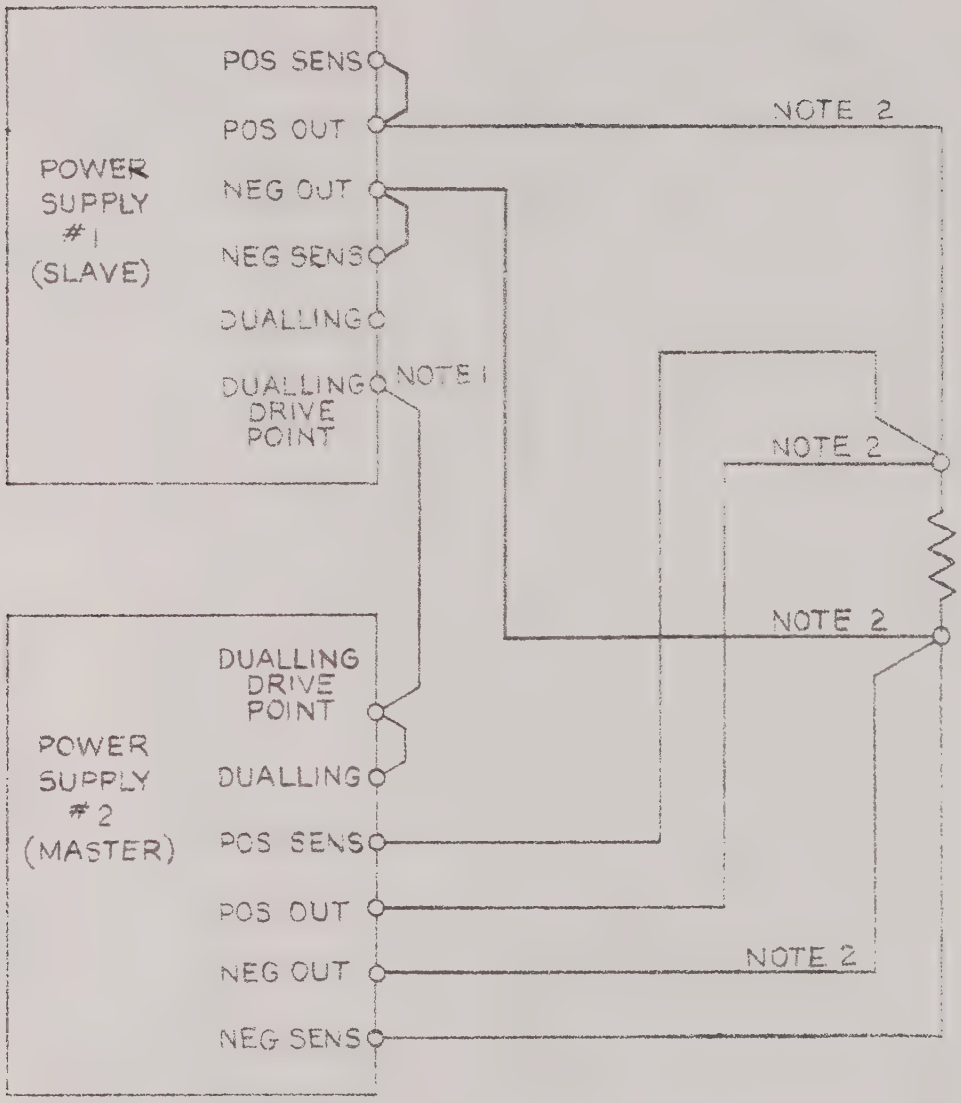


REMOTE SENSING

NOTE 1: REVERSE VOLTAGE DIODE, AS REQ'D. SEE PARA. 2.4.2
SEE OUTLINE DRAWING, SECTION I, FOR TERMINAL CONNECTIONS AND WIRE SIZES.

SERIES CONNECTION

FIG. 2-2A



NOTE 1: JUMPER REMOVED FROM DUALLING TERMINALS ON "SLAVE" UNIT. INTERCONNECT DUALLING DRIVE POINTS BETWEEN "MASTER" AND "SLAVE" UNIT. SEE OUTLINE DRAWING, SECTION I, FOR TERMINAL CONNECTION AND WIRE SIZES, INCLUDING DRIVE POINT.

NOTE 2: LOAD LINE RESISTANCES SHOULD BE BALANCED CLOSELY FOR OPTIMUM OPERATION.

PARALLEL CONNECTION

FIG. 2-2B

SECTION III

THEORY OF OPERATION

3.1 GENERAL:

A simplified block diagram illustrating the basic elements of the circuit and the signal flow, is shown in Figure 3-1. The AC line voltage is transformed to adequate values to supply the Rectifiers and Controlled Rectifiers through the main transformer. The firing circuit and transistor amplifier voltages are obtained from the auxiliary transformer and an associated AC to DC rectifier and filter system. On some models, the main and auxiliary transformers are one unit with separate windings, see Figure 3-1. The average value of the signal from the SCR is filtered by a capacitor input filter. The control of the average voltage across the capacitor input filter is accomplished by control of the firing point of the SCR, and will be discussed later. The output voltage furnished to the load by the series regulator is monitored by a feedback amplifier, which compares this voltage with a stabilized reference voltage, and amplifies the difference between the two voltages. The output of the amplifier is used to control the series regulator in such a way that it counteracts any change in the DC output voltage, thereby furnishing an essentially constant voltage to the external load. The controlled rectifier is basically a device which controls the magnitude of average DC voltage at the capacitor input filter in such a way as to maintain the storage voltage across the series regulator within its dissipation capabilities.

3.2 DETAILED CIRCUIT DESCRIPTION:

Circuit references in the following material apply to the schematic diagram at the back of the manual. This diagram shows electrical relationships, and is laid out in an arrangement approximately the same as that of the Block Diagram, Figure 3-1.

3.3 The power supply is energized by connecting 115 volts (nominal) 60 cycles, to the input terminals (TB1-1 and TB1-2) -or (TB1-1 and TB1-3) on model CR36-50 - and closing switch (S1), attested by the lighting of pilot lamp (DS1).

3.4 The power transformer winding (S) converts the input line voltage to an appropriate value, which is rectified to a pulsating DC output voltage by rectifier assembly (AA) and (L). This DC voltage is then filtered by capacitor (C1), and applied through a regulating transistor assembly (A) to the external load. Capacitor (B) provides additional filtering of the output, and reduces the internal impedance of the supply for medium frequency load variations.

3.5 The output voltage on the auxiliary winding (W) is rectified by diodes (CR101 and CR102) and (CR103 and CR104), and filtered by capacitor input filter (C102)-(AK) to provide positive and negative operating potentials for the feedback amplifier. Zener diode (CR109) in conjunction with its load resistor (C), provides regulated + 18 VDC: while diode (CR110) with resistor (D) provides -18 VDC (measured with respect to the negative output terminal of the unit). These zener diodes function in a manner analogous to that of a gaseous voltage regulator tube, providing a relatively constant output voltage across their terminals despite variations in the conducted current. Transformer winding (U) feeds (A2), the controlled rectifier firing circuit. The function of this circuit will be described later.

3.6 The feedback amplifier consists of three stages of amplification, the first two of which are balanced amplifiers, assuring minimum sensitivity to fluctuations in ambient temperature or operating voltages. The input signal for the amplifier is derived from a voltage sensing divider connected across the output of the supply. This divider consists of resistors (E) and (F) in the amplifier, and resistor (G) on the main chassis. The resistance setting of (G) determines the operating value of the DC output voltage of the supply in a manner which will be explained below. Resistor (G) is connected to the output voltage control knob on the front panel. (F101) at the base of (Q108) provides protection for both the precision feedback resistor (G) as well as the transistor differential amplifier during surges arising because of transient load conditions.

3.7 The negative end of the sensing voltage divider (negative end of resistor) (F) is returned to the negative output of the supply through zener diodes (CR111) and the negative sensing lead. The diode, in conjunction with its load resistor (H), provides a highly stable potential of 6 VDC for use as a comparison voltage by the input stage (Q107 and Q108) of the feedback amplifier. When the output of the power supply (measured at the load) is precisely at its selected nominal value, the voltage at the base of (Q108) is at the same level as the base of transistor (Q107), and the input stage is in balance.

3.7 (cont'd)

Under this condition, any tendency of the load voltage to vary in either direction will unbalance the amplifier, resulting in corrective action which compensates for the impending change, and holds the load voltage at its established value, as explained below.

3.8 Transistors (Q107 and Q108) are PNP type units, operated in common-emitter mode, and connected as a balanced differential amplifier. Their outputs, taken across load resistors (I) and (J) are direct-coupled to the bases of the succeeding differential amplifier stage (Q105)-(Q106), which consists of two NPN transistors operated in common-emitter mode. The output of (Q105), from its load resistor (AD), drives the base of the single ended output stage (Q104). The output of the amplifier at the emitter of (Q104) is tied directly to the base of the driver transistor (Q101) on model CR-36-50 an additional stage of gain is provided by transistor (BC). In this case, the output of (Q101) is tied to the base of transistor (BC).

3.9 Regulation of the DC output is performed by a double regulating system. A transistor series regulator consisting of power transistors (A), operating in parallel, provides high-speed regulating action to correct for ripple and transient variations both at its input (AE-AB) and at the output of the supply. The amplifier loop which provides correction signals to the series regulator is driven directly from the output through the feedback resistor divider and is comprised of transistor (Q108, 107, 106, 105, 104 and driver transistor Q101). On model CR36-50 transistor (BC) is added. A silicon controlled rectifier (L), which is driven by the components of (A2), is designed to regulate the "storage" voltage across the series regulator. The circuit is such that regardless of the output load requirement, the power dissipation of the series transistor regulator is maintained within its rating.

3.10 The controlled rectifier firing circuit (A2) senses the current through the pass transistor (A), as well as the voltage across the pass transistor, to adjust the storage voltage of the pass transistor by controlling the average value of the voltage across (AE-AB). The feedback circuit consists of (M) and (N). The circuit is designed to limit the maximum dissipation in the series regulator. Voltage appearing at the junction of (M and N) is fed to the base of transistor (Z) which drives the controlled rectifier firing circuit (A2). On some models, transistor (Z) is not used (see schematic diagram at the end of this manual). In this case, the voltage appearing at the junction of (M and N) is fed directly to terminal No. 5 of the controlled rectifier firing

3.10 (cont'd)

circuit (A2). In this type of unit terminal No. 4 of the controlled rectifier firing circuit is tied directly to the negative output terminal of the unit. The voltage at the base of (Z) controls the current to the controlled rectifier firing circuit (A2), terminals 4 and 5. The current flow through terminals 4 and 5 determines the firing point of the controlled rectifier as explained below. Thus, a change in the voltage across the pass section triggers the silicon controlled rectifier in such a manner as to change the average voltage at (AE-AB), so that the power dissipation in the pass section is maintained at a safe operating level.

The operation of the firing circuit (A2) is accomplished in a novel way to achieve a wide range of firing control of the CR gate. This control is from approximately 15° to 165° of each half cycle. The firing point is varied by setting the level of the base current of (Q2). The method of creating the firing pulse is by switching (Q4) on and off. This is accomplished with the following sequence of events; (C2) acts as the storage capacitor to set the bias levels for (Q1), (Q3) and (Q4). (Q1) conducts and charges (C1) when the emitter of (Q1) is more positive than the voltage at the base. The transformer winding and rectifier and the combination of (CR3) and (R1) allows the emitter to go positive at some point during the pulsating voltage. The current flow through (Q1) charges (C1). As (C1) discharges through (Q2), the base of (Q4) is driven in a negative direction until (Q4) is switched to the conducting state. The discharge of (C1) through (Q2) is controlled at the rate determined by the effective resistance presented to the discharge current. Therefore the full range of firing is controlled by the relatively small base current of (Q2). The switching on of (Q4) is controllable through almost all of the half cycle. Capacitor (C3) provides regenerative feedback to switch the transistors (Q3) and (Q4) "on" and "off" rapidly. The pulse thus established is transmitted to the controlled rectifier through pins 6 and 7 of (A2).

Storage voltage control of series regulator (A) is achieved in the following manner. Suppose the Output Adjust (G) is varied to produce a reduced output voltage. Since the series regulator's response is much faster than the controlled rectifier, a momentary situation develops in which the series regulator voltage increases i.e., the voltage (AE-AB) holds momentarily while the output voltage is reduced. As described above, when the series regulator voltage increases, the storage regulator amplifier loop causes the controlled rectifier output to restore the original series regulator voltage. In this case, the

3.10 (cont'd)

voltage at (AE-AB) drops to compensate for the output voltage reduction. It is thus seen, that the controlled rectifier output (AE-AB) tends to "track" the output voltage; and in this manner maintains the series regulator dissipation within fixed limits.

3.11 The regulating principle through the series regulator feedback circuit is to maintain balance at the bases of (Q107 and Q108). These bases will maintain balance within a small voltage which is the error voltage due to feedback loop gain level. Due to the high gain of the system, the error voltage will be small, and at maximum, equal to the maximum allowable error of the equipment. The sequence of operation begins by an adjustment of (G) or by any change in current through (G). Either change will unbalance the base of (Q108) with respect to (Q107) base. The system will adjust itself up or down until the voltage level at both bases are equal. Any load or line change will unbalance the amplifier and require corrective action. One such action will be described. The other disturbances cause the circuit to react in a similar manner. If we wish to raise the output voltage, then the value of (G) is increased. This increase momentarily decreases the voltage at the base of (Q108). The error is amplified through the system and a signal is applied to the base of the series regulator transistor (A) in such a manner as to decrease its storage voltage. The controlled rectifier at the same time raises the average level at (AE-AB). The rise in the output was such that the voltage at the output terminals divided by the value of (G) is equal to the zener voltage (CR111) divided by (E) and (F).

3.12 The sensitivity and speed of response of the corrective feedback circuit is such that the above-described action occurs almost instantaneously, and the actual excursion of the load voltage is held to a very small value. The circuit is a true proportional regulator, and must allow a small but finite "error" to exist between the required and actual regulated voltage, so that this "error", however small, can generate the correction signal. By proper circuit design, however, the error is held to a value which remains within the specified regulation allowance of the power supply.

3.13 When resistor (G) is readjusted to produce a different value of output voltage, the circuit makes a correction similar to that described above. Altering the resistance in the sensing voltage divider unbalances the input stage of the feedback amplifier, which then causes the circuit to produce a new value of voltage such that the drop across resistors (E-F) again equals the drop across diode (CR111).

3.13 (cont'd)

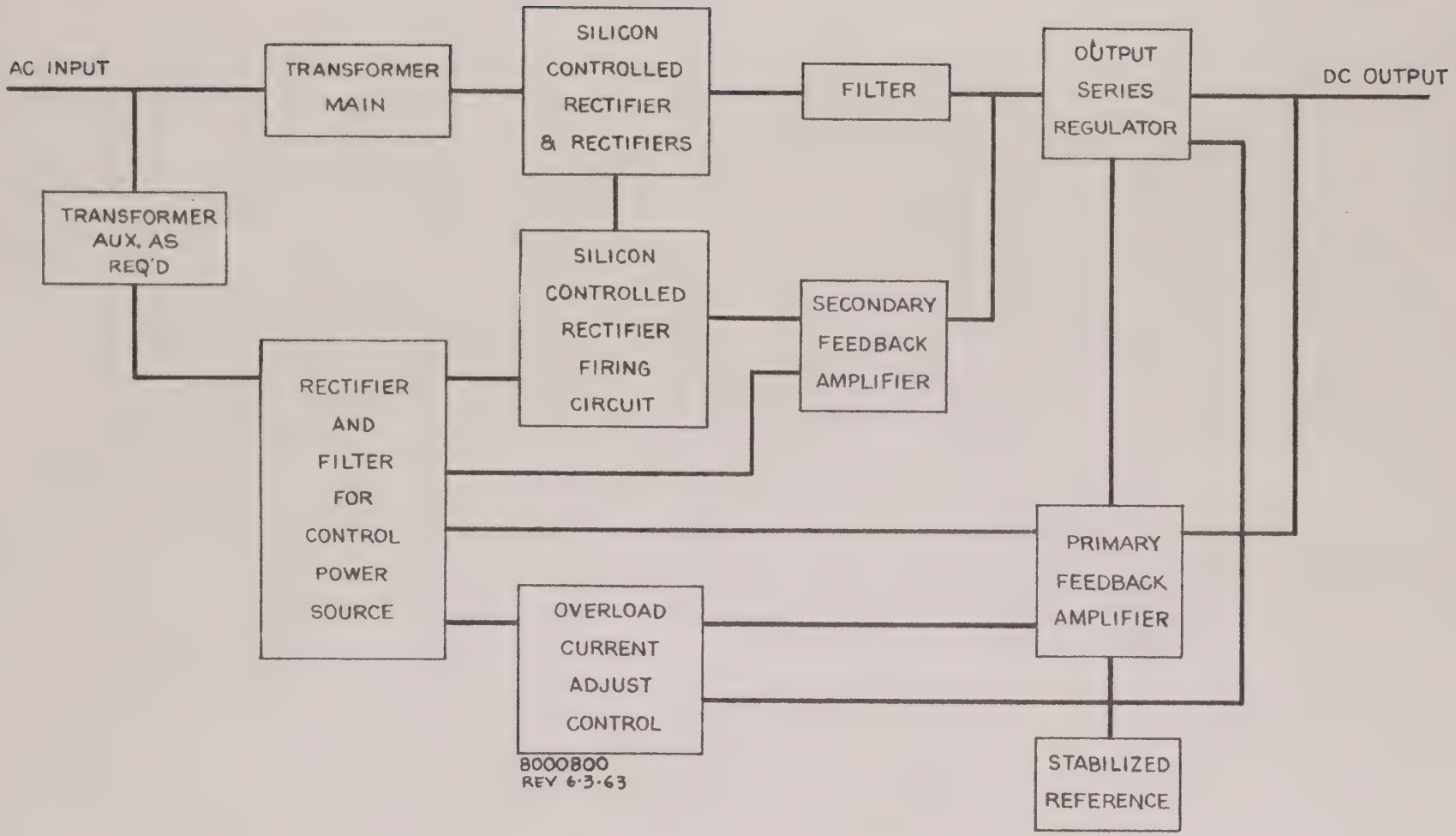
Reducing the value of resistor (G), for example, momentarily increases the drop across (E-F). However, this unbalanced condition at the amplifier input causes the DC output voltage to decrease until the drop across (E) and (F) again equals the drop across (CR111); and the circuit stabilizes at this new operating point, establishing a lower value of DC output voltage. See description of corresponding storage regulator action in paragraph 3-10.

3.14 Resistor (F) in the amplifier is provided to permit compensation for manufacturing tolerances in diode (CR111), its load resistor (H) and resistor (E). This resistor (F) is adjusted at the factory (and locked). If any of these components are replaced, check to see that full rated output voltage of the supply is obtainable with the voltage control at maximum clockwise position. If not, readjust (F) to provide full output voltage under these conditions.

3.15 Variable Current Limiting is accomplished by means of circuitry of (A3) and Current Control potentiometer (AF). The overload current limit circuit operates in such a manner as to limit the output current from series regulators (A) to the setting of CURRENT CONTROL (AF). The action of the circuit may be described as follows: (AF) is a voltage divider resistor feeding the base of (Q302). The emitter of (Q302) is connected to the base of (Q101), the main series regulator driver transistor. The voltage level at this point varies with output load current developed across the emitter resistors of the series regulator transistors. Thus, when the load current attains a value high enough to cause the voltage at the emitter of (Q302) to drop below the preset base level, transistor (Q302) begins to conduct. This causes current flow through (R301) which then forces (Q301) to conduct. This action effectively clamps the base drive at (Q104) through diode (CR302). The action is quite sharp once conduction begins. Prior to conduction, the diode (CR302) effectively decouples the overload circuit from the main amplifier. The circuitry of (Q303), (CR301 and CR303) and (R307 and R308) is provided to protect the series regulators (A) from over dissipation during short circuit when the storage voltage across the series regulators may attain a very high value until the controlled rectifier is able to decrease the average voltage at (AE-AB). This circuit acts as follows: a voltage divider consisting of resistors (R307) and (R308) is connected between the +18 VDC, bias point and the collectors of the series regulators (A). The junction of these resistors is connected to the base of (Q303) whose

3.15 (cont'd)

emitter is tied to the negative output terminal of the supply. If the storage voltage across (A) increases beyond a point determined by (R307) and (R308), transistor (Q303) is turned on. This clamps the base of driver transistor (Q101) to the negative output of the unit cutting off its drive current to the series regulators. This action decreases current flow from the series regulator (A) to a very low value until the controlled rectifier decreases the average value of voltage at (AE-AB). This action keeps the dissipation of the series regulators at a safe value at all times. This circuit overrides the current limiting circuitry during short circuit overload conditions on the output of the power supply, and is designed to protect the series regulators (A).



FUNCTIONAL BLOCK DIAGRAM

FIG. 3-1

102755

SECTION IV

MAINTENANCE

4.1. GENERAL: Reference drawings for this power supply are provided in Section V. The exact Schematic Drawing is shown in Figure 5-1. Physical location of components is indicated in the Parts Placement Drawing in Figure 5-2.

This supply is designed for stable operation over long periods of time. However, if trouble develops, standard test equipment normally found in the Electronics Laboratory would be required. If the customer decides to do complete servicing on his premises, one or more of the following pieces of test instruments are required.

Instrument	Range	Remarks
DC Differential Voltmeter	0-500V	Precise regulation check
Oscilloscope	General Purpose	General troubleshooting
Vacuum Tube Voltmeter	General Purpose	Ripple measurements
Multimeter (Ohmmeter)		General troubleshooting
AC Voltmeter (Precision)	0-150V	Precise regulation check
Variable Autotransformer	0-140 V AC 8A	General troubleshooting
Dummy Load	Range depends on supply rating	

WARNING ! !

THE POWER SUPPLY SHALL
BE DE-ENERGIZED WHENEVER
ANY COMPONENTS ARE REPLACED.

4.2.1 PREVENTATIVE MAINTENANCE: The principal item that will require attention is the cooling arrangement. The power supply generally requires some amount of convection air currents for cooling purposes. Some high power units have forced air cooling. If the air currents are dust laden, a problem may arise that can lead to premature component deterioration.

This condition reduces the cooling efficiency of the supply. We therefore, recommend a periodic cleaning if dusty climate prevails.

CAUTION !! "

VACUUM CLEANER MAY LOOSEN THE
SMALL PLUG-IN TRANSISTORS.

4.2.2 PROCEDURE FOR OILING THE ROTRON MUFFIN FAN: The fan (if provided) may require oil if operated under extreme environmental conditions. The fan in corporates the latest electrical and mechanical advances in the motor design and offers reliable performance for 2 to 5 years under favorable conditions of temperature and vibration without the necessity of oiling. Its life is in inverse proportion to these factors. For example, at 110° F the fan may be expected to give reliable performance in excess of three years and at 40° F reliable performance is extended beyond five years.

If the power supply (equipped with fans) should be installed in areas of greater heat, or severe vibration, the life of the fan may be extended by periodic oiling (a small amount once per year) which is absorbed by the bearing. For this oiling procedure, an OIL INJECTOR NJE Part No. 021988 is required and may be ordered from NJE Corporation. This OIL INJECTOR will service from 15 to 20 FANS. For refills order Fan Lubricant NJE Part No. 020923 in 4 oz. can.

Procedure:

Step 1: Remove cap from end of OIL INJECTOR.

Step 2: Place needle at the center of circle marked on the Gold Label.

Step 3: Position the needle at an angle of approximately 45° to the surface of the label and tangent to the perimeter of the circle.

Step 4: Pierce the label and the concealed self-sealing rubber cap located under the label.

Step 5: Insert the needle approximately 1/4".

Step 6: Depress the plunger of the OIL INJECTOR slowly to the next calibration mark which will allow 1/16" of oil to escape.

NOTE: It is better to give a little more oil than not enough. However, do not overflow the well. If the ambient temperatures are extremely hot, it may be advisable to oil more frequently to insure the optimum performance characteristics of the fan.

4.3 MEASUREMENTS AND TESTS

4.3.1 Sensing Connection: Sensing lead connections are of utmost importance in making proper regulation measurements. It is recommended that the sensing connections be made directly at the output terminal points rather than at a remote load point. Although the regulation measurement should check correctly at a remote point as well as at the supply terminals, it is well to ascertain that the power supply itself is operating properly without introducing the possibility of extraneous external wiring problems. Thus, all measurements should be made with "local" sensing connections, i.e., with the Sensing terminals jumpered directly to the corresponding Output terminals. One other point of caution in proper measurement technique is the following:

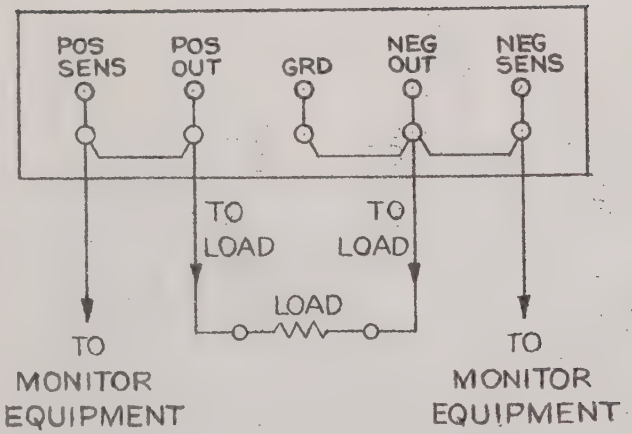
> It is absolutely essential that the measuring equipment connections be made directly to the sensing terminals, whereas the load lead connections must be made directly to the Output terminals. Figure 4-1 shows proper and improper connections for measurements taken with "local" and "remote sensing" connections.

Various measurements can be made using essentially the same connections, but using different instrumentation. The following paragraphs describe the basic parameters which may be tested.

4.3.2 Regulation Checks: Since regulation of modern power supplies can be as low as 0.001%, special measuring techniques must be employed to accurately check the various regulation parameters. It is necessary to use an external source of DC voltage of approximately the same value as the power supply output as a "bucking" source, connected as shown in Figure 4-2. This DC bucking voltage can be either an electronic, null balance differential voltmeter, or a group of batteries connected in series (or another power supply), furnishing a DC potential slightly larger than the output voltage of the power supply under test. When using an differential voltmeter, the voltmeter is built right into the test equipment. When a "bucking" battery is used the voltmeter should have a full-scale range low enough to detect the magnitude of regulation expected.

A multi-tester used on the 1 volt range will usually be adequate, since approximately 10 millivolts can be observed reasonably well. The point to note here is that the voltmeter is used to measure only the difference between two almost equal voltages. The balance adjustment (either in the electronic unit, or the test set-up of the diagram) is used to bring the meter needle to approximately midscale before testing, so that the deviation above or below the normal output of the supply under test can be observed.

CORRECT



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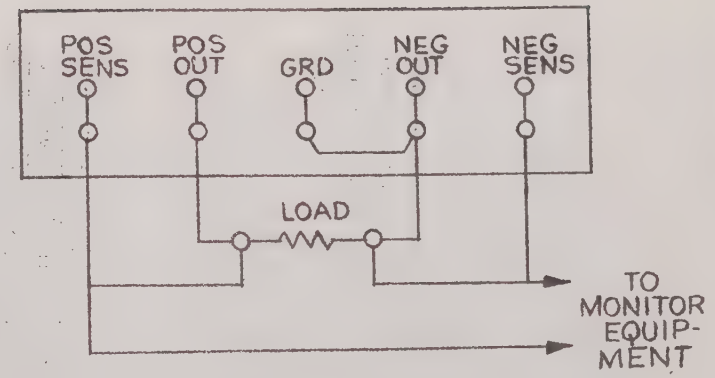

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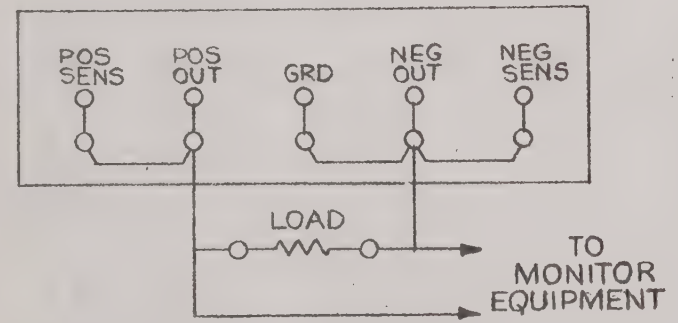
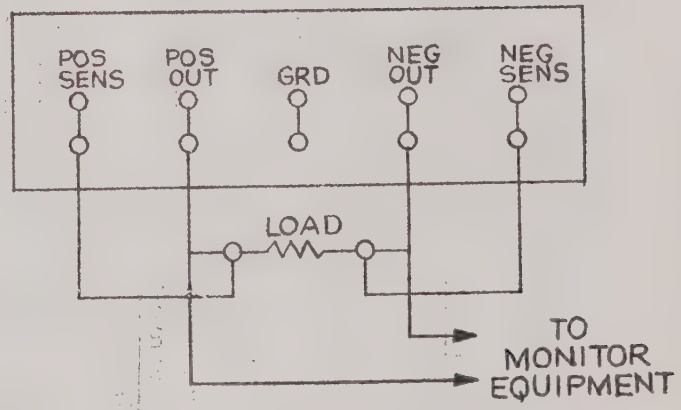


INCORRECT



LOCAL SENSING

REMOTE SENSING

MEASUREMENT CONNECTIONS WITH LOCAL SENSING AND REMOTE SENSING

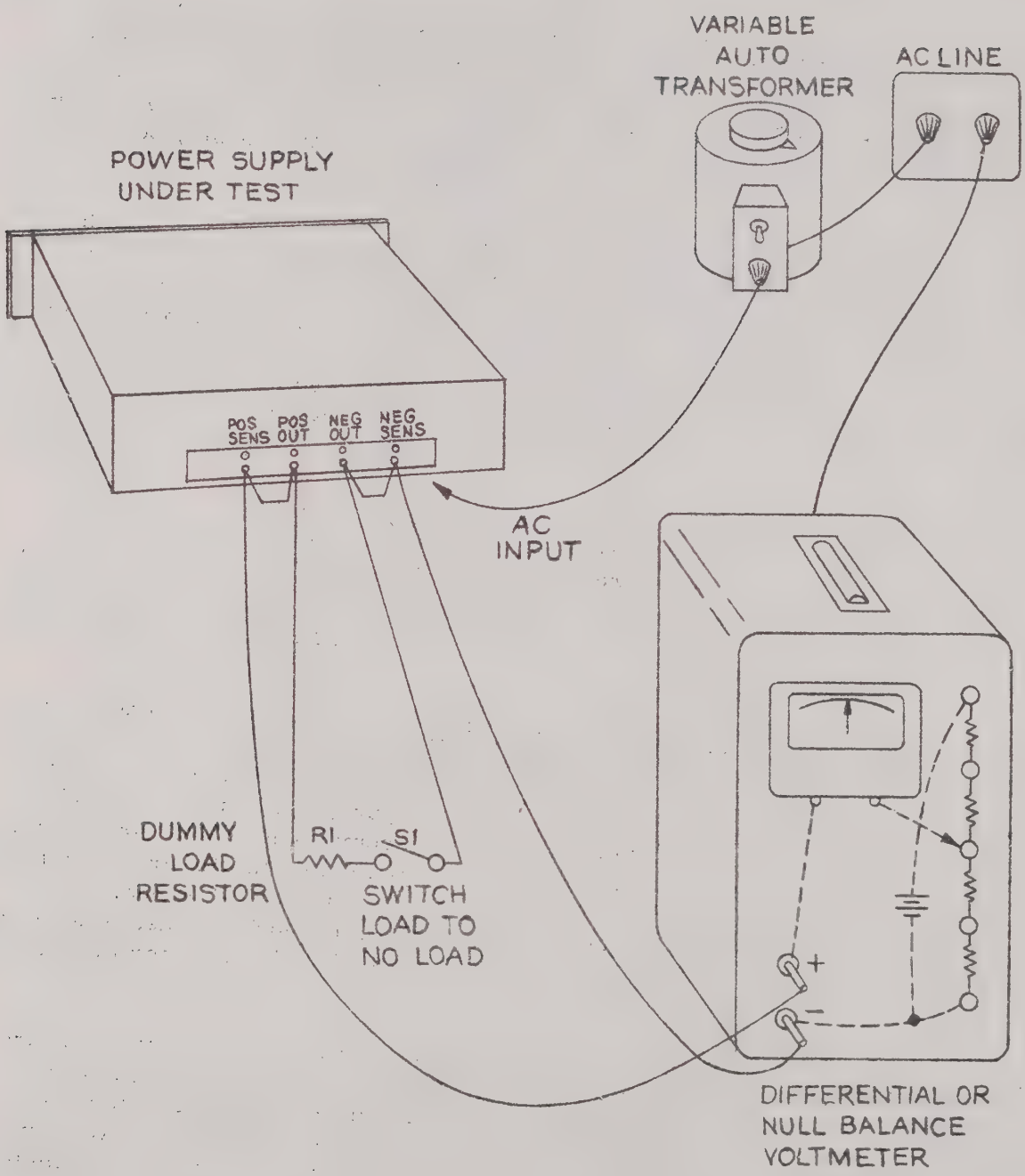
4.3.3 Static Load Regulation: The dummy load (R1) of Figure 4-2 is selected to draw full load current at the nominal output voltage of the supply. The difference between the differential voltmeter readings with the switch open and closed (allowing the needle to come to rest before reading), gives the static load regulation in volts. When load changes are made, it may be necessary to readjust the line voltage to its nominal value.

4.3.4 Static Line Regulation: With the load set at some fixed value, either no load, full load, or some in-between point, the input line is varied by means of the variable auto-transformer shown in Figure 4-2. Note that if this measurement is made under a heavy load condition, the auto-transformer must be selected to supply the necessary input volt-amperes. The difference between the differential voltmeter reading for different line voltage conditions (allowing the needle to come to rest before reading), gives the static line regulation in volts.

4.3.5 Ripple: Either a sensitive VTVM or oscilloscope may be connected directly across the power supply sensing terminals for this measurement. The same set-up as used for the regulation checks may be used if it is desired to observe the ripple under different conditions of the voltage and load current. Be sure to make the measurement connections at the sensing terminals rather than at the load terminals.

4.3.6 Dynamic Regulation and Recovery Time: In the test-set-up described above for Static Load or Line Regulation, a calibrated oscilloscope should be substituted for the differential voltmeter. Maximum deflection and recovery time are measured directly as a dummy load of appropriate value is switched in and out of the circuit. A mercury switch is recommended to minimize arcing, or else an electronic switch should be used. If available, the latter is highly desirable, since the response is readily displayed on the oscilloscope. If recovery time is the parameter under investigation, the switch must be such that the rise and fall time of the current step be at least five times faster than the anticipated recovery time.

4.3.7 Stability: A detailed check for improper drift and intermittent failure can be made by utilizing the same test arrangement as for static regulation measurements. The only requirement is that the differential voltmeter used must have stability of an order of magnitude better than that of the power supply. If available, a stable recorder may be substituted for the differential voltmeter in the drawing, thereby procuring a continuous tracing of the power supply stability.



REGULATION CHECK
TYPICAL LAYOUT

FIG. 4-2

4.4 MALFUNCTIONS: The various ways in which DC power can deviate from normal operation are listed below. Each condition is treated separately in the charts that follow. Component symbol designations refer to the schematic diagram at the rear of the manual. Parts locations are indicated in the parts placement diagrams also included at the rear of this manual.

MALFUNCTION	TYPICAL MAGNITUDE
1. No output voltage at any control setting.	Zero or DC output voltage.
2. Low output voltage.	Maximum output voltage obtainable at no load is less than maximum rating.
3. High output voltage.	Minimum output voltage obtainable at no load is more than maximum rating.
4. Failure to regulate.	Output voltage drops 5% or more when load is applied, for varies ±2% or more under a ±10% variation in line voltage.
5. Poor regulation.	Regulation better than above, but not within specification.
6. Excessive ripple.	
A. With good regulation	RMS ripple exceeds specification, but regulation is within specification.
B. With poor regulation	RMS ripple exceeds specification, and regulation exceeds specification.
7. Instability.	
A. Random large excursions	Output voltage "hops" intermittently by 5% or more, with constant load, and constant line voltage.

MALFUNCTION	TYPICAL MAGNITUDE
B. Gradual drift in one direction.	Output voltage changes by 1% or more per minute, after a 15-minute warm-up.
C. Excessive drift under heavy load only.	Output voltage changes by 1% or more per minute, after a 15-minute warm-up but only after application of a heavy load.
8. Inadequate transient suppression.	Failure to "zero-lag". Upon sudden application of a full-load increase, output voltage dips sufficiently to cause a visible momentary deflection of the voltmeter needle.
9. Oscillation	
A. High frequency.	Under constant load, output voltage is modulated by sawtooth or sine-wave with frequency of 200 cycles or more per second.
B. Low frequency.	At constant load, output voltage exhibits relaxation modulation at or below 200 cycles per second.

4.4.1 No Output Voltage At Any Control Setting

SYMPTOM	POSSIBLE CAUSE	REMEDY
A. Pilot light (DS1) not lit.	1. No line power, or defective input connection	1. Check power source lines and connections.
	2. Input fuse or fuses (AG) blown. Control fuse or fuses (BE) blown.	2. Replace fuse. If fuse blows repeatedly, do not overfuse.
B. Repeated blowing of fuses (AG) or (BE).	1. Shorted rectifiers (AA) or (L).	1. Replace rectifier, or rectifiers.
	2. Shorted rectifiers on (A2, CR1 or CR2) or on (A1, CR101, CR102, CR103 CR104).	2. Replace rectifier or rectifiers.
C. Fuse (AG) blown.	1. External	1. Check for overload.
D. Unregulated DC across (AE) zero or low. "Fuse (AG) not blown".	1. Open rectifiers (AA) or (L) (CR101, CR102 CR103, CR104, or on A2, CR1 or CR2).	1. Replace rectifier or controlled rectifier.
	2. Primary or secondary transformer open.	2. Replace transformer.

NO OUTPUT VOLTAGE AT ANY CONTROL SETTING (cont'd)

SYMPTOM	POSSIBLE CAUSE	REMEDY
E. Unregulated DC present at (AE) but more than 15-25% higher than DC output.	1. Entire, or major part of unregulated DC voltage across (AE) absorbed by regulator transistor (A). Caused by short or excessive leakage between base of driver or regulator transistors (Q101) (BC) or (A) respectively and any positive voltage or ground. (For example: If positive output is operated at chassis ground and chassis.	1. Inspect for short. Isolate driver transistor from heat sink and chassis, and operate unit for brief interval. If this restores normal operation, replace driver insulation, and/or driver itself, as necessary. If not cleared, repeat for regulators (A).
	2. Amplifier or sensing circuit defective.	2. Check by momentarily shorting base of collector of (Q101). If DC output is restored, amplifier or sensing circuit is at fault. See end of this section for amplifier check.
	3. Rate sensing capacitor (AH) shorted internally, or by external wiring short.	3. Inspect for short. Disconnect one terminal of capacitor. If DC output is restored, replace capacitor.
	4. Defective driver transistor. (Q101) also (BC) on model CR 36-50.	4. Check by momentarily shorting base to collector on driver transistor at no load. Replace driver transistor.
	5. Ammeter (M1) open.	5. Check by momentarily shorting meter terminals. Replace.
	6. Resistors (P) all open.	6. Replace defective resistors.
	7. On (A2) shorted (Q303) or open (R307)	7. Replace defective components.

4.4.2 Low Output Voltage Relative To Voltage Adjust Setting.

SYMPTOM	POSSIBLE CAUSE	REMEDY
A. Unregulated DC present at (AE) in expected magnitude (15% to 30% higher than output voltage at nominal line voltage at no load).	1. Amplifier or sensing circuit defective.	1. Check by momentarily shorting base to collector of (Q101). If this restores DC output, check sensing voltage divider. See end of this section for amplifier check.
	2. Rate sensing capacitor (AH) has excessive leakage.	2. Disconnect one terminal of capacitor. If this restores DC output, replace capacitor.

4.4.3 High Output Voltage

SYMPTOM	POSSIBLE CAUSE	REMEDY
A. Output voltage adjust knob has little or no control over DC output.	1. External sensing circuit improperly connected. Internal sensing voltage or wiring open.	1. With power off, check continuity of sensing leads, internal sensing circuit from positive output terminals to amplifier input and from negative output terminal to neutral bus of amplifier.
B. Output control effective, driver base (Q101) negative with respect to negative output terminal.	1. a. Bleeder resistor (A1) open, or regulator transistor (A) I_{CO} drain open resistor (AJ) and (JA) or (BE) on model CR 36-50.	1. a. Check by applying full load. If this restores normal operation, check for open resistor or connection.
	b. Defective amplifier.	b. See amplifier check at end of this section.
	c. Defective amplifier power supply.	c. Check voltage across filter capacitor (C102) (C103) or (AK) as shown on schematic diagram. If current, check resistors (C-N) for open.
		d. If incorrect, check the capacitors, (C102, C103) diodes (CR101 thru CR104) and secondary winding of transformers.

SYMPTOM	POSSIBLE CAUSE	REMEDY
C. Driver base (Q101) positive with respect to negative output terminal.	1. Defective driver and/or pass transistor on model CR 36-50 check transistor (BC) also.	1. Check for shorted transistors.

4.4.4 Failure to Regulate

SYMPTOM	POSSIBLE CAUSE	REMEDY
A. Load regulation is 5% or more, line regulation 2% or more.	1. a. Defective amplifier	1. a. See amplifier check at end of this section.
	b. Defective amplifier power supply.	b. Check voltage values of filter capacitors (C103 C102). If incorrect, check the capacitors, diodes (CR101 thru CR104) and main secondary winding of transformer. Check (D) and (C) for open.
	c. Very low performance transistor in regulator or driver circuit.	c. Check for equal voltages across resistors in series with emitter of power transistors, to detect defective transistor, check transistors in a transistor test set or by substitution.
	d. Failure in adjust current limiting circuit.	d. Check transistors first then carefully check other parts for open or shorts and replace any defective components found.

4.4.5 Poor Regulation

SYMPTOM	POSSIBLE CAUSE	REMEDY
A. Load regulation less than 5%, but not within specification.	1. External sensing circuit incorrectly connected.	1. Check by operating unit with sensing terminals temporarily jumpered to the local output terminals. (Observe correct polarity).
	2. Low gain amplifier.	2. See amplifier check at rear of this section.

SYMPTOM	POSSIBLE CAUSE	REMEDY
	3. Low beta in driver or power transistors.	3. Check by substitution or in transistor tester beta of 20 or more is acceptable.
	4. Oscillating amplifier.	4. Check (AL) for proper value. See amplifier check at rear of this section. on model CR 36-50 check (C5) also.

4.4.6 Excessive Ripple

SYMPTOM	POSSIBLE CAUSE	REMEDY
A. Output regulation is within specification.	1. a. Circuit not bypassed to ground.	1. a. One output terminal of the supply should be connected to chassis ground whenever practical either directly or thru a 0.1 mfd. capacitor of appropriate voltage rating.
	b. Filter capacitor (AE) (C102) or (C103) open or of low value.	b. Replace.
	c. Note: Ripple at (AE) should not exceed 5% of maximum output voltage of unit.	c. Replace.
	d. Rate-sensing capacitor (AH) open or of low value.	d. Replace.
	e. Hum pick-up in external sensing leads.	e. Check by operating unit with sensing terminals temporarily jumpered to local output terminals. Shield external sensing leads.
	f. Low-gain amplifier.	f. See amplifier check at end of this section.

SYMPTOM	POSSIBLE CAUSE	REMEDY
B. Output regulation poor.	1. a. Low beta in power transistors or driver transistors.	1. a. Check by substitution or in transistor test set. Beta of 20 or more is acceptable.
	b. Low gain amplifier	b. See amplifier check at end of this section.
	c. Defective amplifier power supply.	c. Check diodes (CR101 thru CR104) for shorts or open capacitors (C102) (C103) for open, low value, or high leakage. Check diodes (CR110) (CR109) and resistors (C) and (D).

4.4.7 Instability

SYMPTOM	POSSIBLE CAUSE	REMEDY
A. Random large excursions of output voltage.	1. Intermittent failure of component or intermittent short or open in circuit.	1. Check primary power circuit by temporarily connecting base of driver transistor (A) to negative output terminals. If instability persists, check for intermittent breakdown in rectifiers (AA-L) or filter capacitors (AE). Check for intermittent opens or shorts in unregulated DC circuit. Check driver and power transistors in tester, or by substitution. Check for intermittent opens or shorts or defective component from (AE) to output terminals. Look for intermittent open or short, of intermittently defective component in (1) amplifier, (2) amplifier power supply, (3) sensing voltage divider and external sensing circuit and (4) controlled rectifier firing circuit.

INSTABILITY (cont'd)

SYMPTOM	POSSIBLE CAUSE	REMEDY
		Check amplifier connector for poor contact. Check rate-sensing capacitor (AH). Check voltage across (CR109, CR110 and CR111) for stability.
B. Gradual drift in one direction at any load after 15-minute warm-up.	1. a. Defective amplifier.	1. a. See amplifier check at end of this section.
	b. Drifting zeners.	b. Check (CR109), (CR110) and (CR111). Replace if faulty.
	c. Output adjust potentiometer (G) unstable.	c. Replace.

4.4.8 Inadequate Transient Response.

NOTE: This condition should be checked by an oscilloscope at the output terminals of the supply, with the sensing terminals temporarily jumpered to the corresponding output terminals. None of the load current should be permitted to flow through any portion of the oscilloscope leads or the sensing leads.

SYMPTOM	POSSIBLE CAUSE	REMEDY
A. Regulation and ripple are within specification and external sensing circuit is properly and firmly connected.	1. a. By-pass capacitor. (B) open, or very low in value.	1. a. Replace.
	b. Filter capacitor (AE) low in value.	b. Replace.
	c. Failure in oscillation dampers (BF) and/or (AN).	c. Check for defective parts and replace any found low in value, open, or shorted.

NOTE: A brief transient during switching is normal, the measurement of transient response may be complicated by inductive transients of 1 to 50 microseconds duration due to lead inductance, etc., but since these are easily handled by means of local by-passing, they have no significance in determination of the transient response of the supply.

SYMPTOM	POSSIBLE CAUSE	REMEDY
A. Under constant load, output voltage varies at a cyclic rate (sawtooth or sine wave) of 200 cycles or more per second.	1. a. Defective diodes (CR109) (CR110) or resistors (C-D).	1. a. Replace
	b. By-pass capacitor (B) is open or of low value.	b. Replace
	c. Rate sensing capacitor (AH) or its circuit is open.	c. Replace
	d. Suppressor capacitor (AL) in amplifier is open or of low value.	d. Replace.
	e. Suppressor capacitor (C5) on model CR 36-50 is open or of low value.	e. Replace.
B. Under constant load, output voltage varies in "sawtooth" manner at a frequency of 200 cycles or less.	1. a. Output capacitor (B) is open.	1. a. Replace
	b. Rate sensing capacitor (AH) is open, or of low value.	b. Replace.
	c. Excessive capacitance in external load circuit.	c. If load contains capacitance equal to or greater than capacitor (B), special precautions are necessary. Check with NJE Corp. Engineering Department.
	d. Excessive amplifier gain.	d. If the beta (current gain) of one or more amplifier transistors is 150% or more of the manufacturer's bogie value, the increased gain which results (particularly at high ambient temperature) could result in this type of oscillation. Replacement of the transistor is required.
	e. Failure in controlled rectifier firing circuit.	e. Check all transistors first. Then carefully examine all other parts of this circuit. Replace all parts found to be defective.
	f. See Par 4-11 (C)	

4.5. ALIGNMENT AND ADJUSTMENT: The power supply has three controls that are factory adjusted and normally do not require attention in the field. If any of the components in the error-difference amplifier are replaced, the following readjustment procedure may be necessary.

4.5.1 OUTPUT ADJUST calibration

Step 1: Set OUTPUT ADJUST variable resistor (R3) completely clockwise. The unit may be operated at nominal line and at no load.

Step 2: Place calibrated voltmeter across output.

Step 3: Adjust variable resistor (A1 R123) until full rated output is reached.

4.5.2 CURRENT CONTROL calibration

Step 1: Set OUTPUT ADJUST variable resistor (R3) completely clockwise.

NOTE: Verify that the output is the full rated voltage.

Step 2: Set CURRENT CONTROL variable resistor (R7) completely clockwise.

Step 3: Place a calibrated ammeter in series with load.

Step 4: Apply a short circuit to Power Supply through external current monitor.

Step 5: Slowly rotate variable resistor (A3 R305) until current level reaches the 110% limit.

4.5.3 Storage Voltage Adjustment: Storage voltage is a measure of the voltage across the series regulator transistor (A). It varies only slightly with various line and load conditions of the power supply. It is adjusted by activating the power supply by means of (S1) and then adjusting first the no load storage adjust (Q) and then the full load storage adjust (M). A preset value of input voltage to the unit and its output voltage adjustment setting for this test follows in a table for all CR type units. "Full Load" means that the supply is loaded, by means of a dummy load to its maximum output current capabilities.

4.5.3 (cont'd)

The storage voltage adjustment need never be touched unless (CR109), resistor (W), or transistor (Z) are replaced. If any or all of these parts are replaced on the unit, then the storage voltage should be checked from the table and readjusted if needed.

STORAGE VOLTAGE TABLE

Model No.	Storage Voltage No load (adj, Q)	Storage Voltage Full load (adj, M)	Input Line Voltage	Unit Output Voltage
CR18-30	5.0-5.5VDC	4.0-4.2VDC	105VAC	18VDC
CR36-8	None	4.3-4.7VDC	115VAC	36VDC
CR36-15	None	6.4-6.7VDC	115VAC	36VDC
CR36-20	7.2-7.7VDC	2.9-3.3VDC	105VAC	36VDC
CR36-30	None	5.5-6.1VDC	115VAC	36VDC
CR36-50	None	5.2-5.7VDC	208/220VAC	36VDC
CR60-9	None	9.8-10.2 VDC	105VAC	60VDC
CR60-18	None	5.9-6.2VDC	115VAC	60VDC

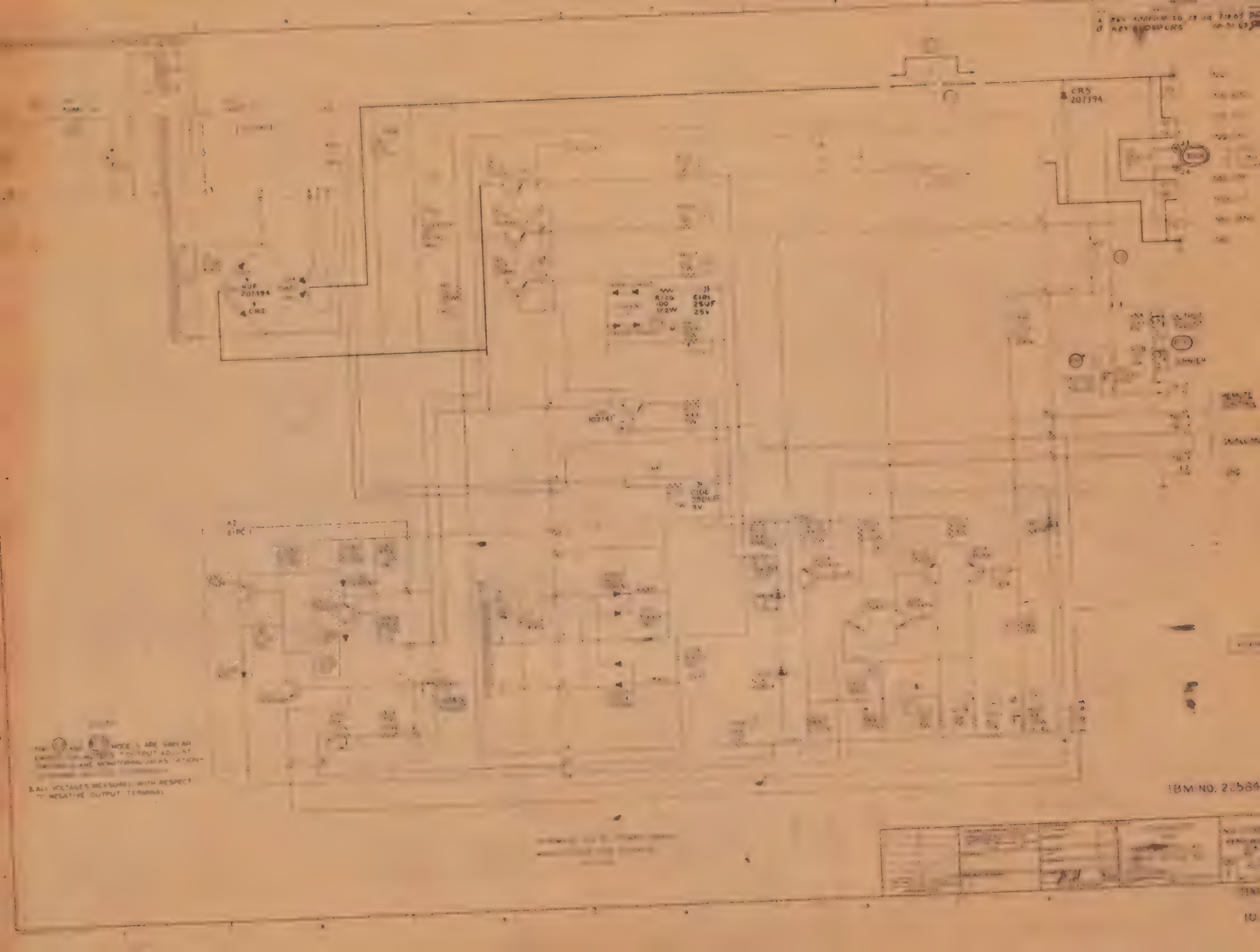
4.6. FEEDBACK AMPLIFIER CHECK: There are several methods which can be used in checking the performance and condition of the feedback amplifier.

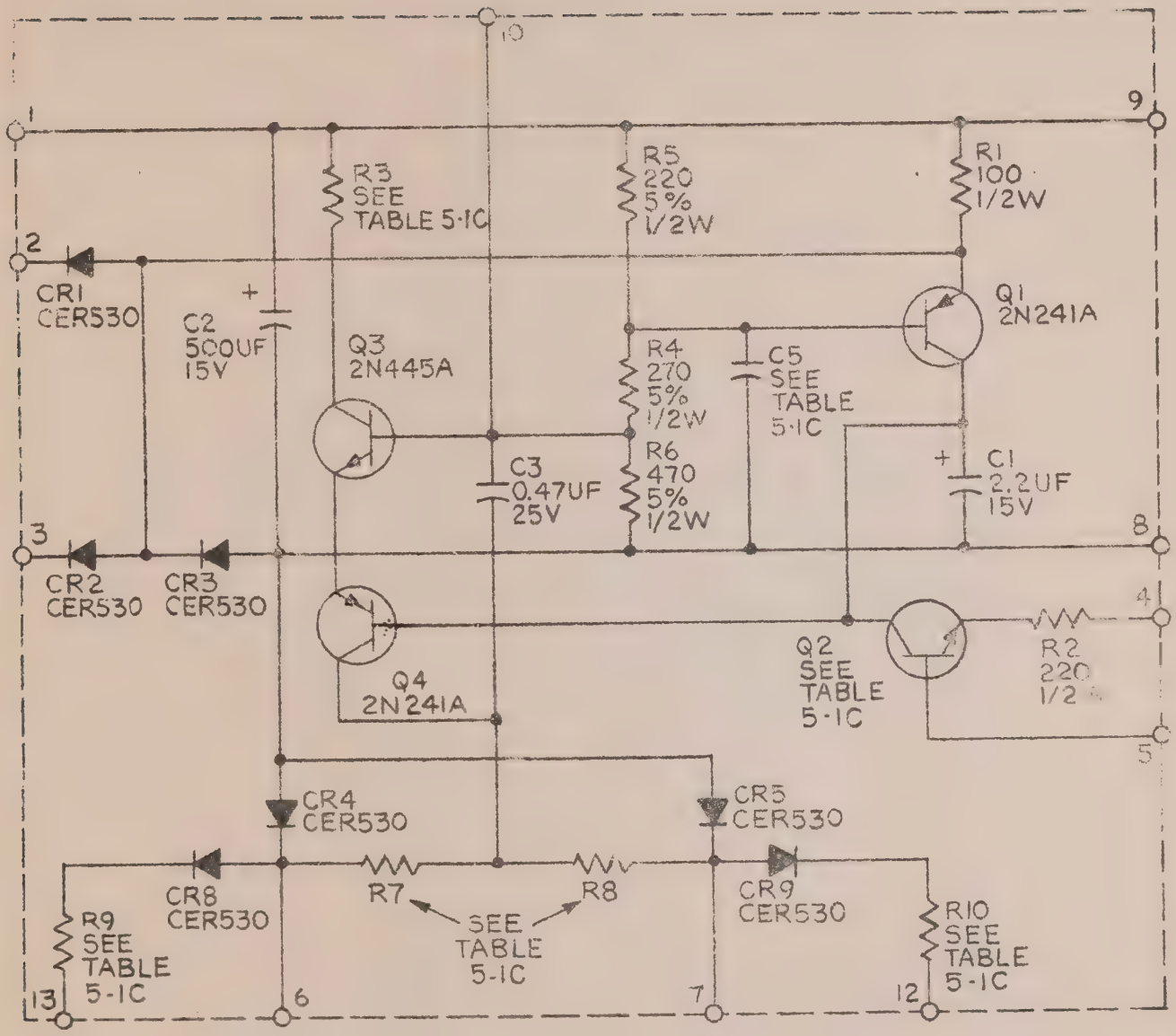
Except for individually removing the transistors for a check by means of a transistor test set, and making continuity and resistance tests on the circuit and components, all methods require the amplifier to be energized with the proper potentials under the conditions found in the power supply for normal operation. For this reason, it is simplest to test the amplifier in position in the supply, first making certain that its DC power supply transformer, rectifiers, diodes (CR109 and CR110) and resistors (C) and (D) are functioning properly. This can be quickly ascertained by checking the circuit voltages as indicated on the schematic diagram. Once this is done, the procedures given below can be used to check out the amplifier itself.

4.6.1 Voltage Check: The simplest and most rapid direct check of the amplifier is made by connecting a temporary jumper from the base of transistor (Q107) to the base of transistor (Q108), thereby balancing the amplifier input stage, and checking for balanced voltages on the two defective stages, and simple analysis will pinpoint the defective connection or component. Verification is then made by testing the component itself or repairing the connection.

4.6.2 Signal Tracing Check: Since there is an inherent amount of ripple at the input to the amplifier, this ripple signal can be used as a test signal for observing the amplifier performance with the aid of a test oscilloscope, (ignore any spikes in the waveform. Use only the basic ripple signal when making amplitude calculations) in the event that the ripple is too small for practical use, a small 60-cycle sine wave voltage of convenient amplitude (less than 1/4-volt) can be injected into the amplifier, applying it across the amplifier terminals on printed circuit board for convenience. Measurement of the ripple at the input to the amplifier, and at the output of each successive amplifier stage will provide an effective check of amplifier performance. The ripple amplitude measured across the bases (or input) of the second stage transistors (Q105 and Q106) should be 20 to 40 times the amplitude at the input to the first stage. The ripple at the base of the next stage, transistor (Q104) should be 15 to 30 times the ripple at the input to the previous stage. The ripple at the output terminal of the amplifier should be roughly the same as the input to transistor (Q104). Radical departure from this set of conditions will point up a defective component or connection, which can then be isolated by inspection and individual test. Be sure not to overdrive the amplifier stages as it will cause misleading results.

4.7. STABILITY CHECK: A detailed check for improper drift and intermittent failure can be made by utilizing a test rip similar to that shown for precise regulation check in Figure 4-3. The voltage across the zener diode reference source (CR111) is "bucked out", and monitored by a 0 to 1-volt (or smaller scale if available) high impedance DC voltmeter (null balance voltmeter). Drift or random instability will be readily visible in this test. Output voltages of the successive amplifier stages and regulating dodes (CR109) and (CR110) can then be monitored in the same manner. When checking a given amplifier stage by this method, the output of the previous stage should be shorted, to prevent external voltage variations from reaching the stage under test. When installing a new transistor in place of one shown to be defective, the stability check should be repeated, to make certain that the trouble has been eliminated.


CR5
207394
CR2
R126
100
1/2W
C101
25µF
25V
IC2141
C106
.05µF
3V
A2
BIPC
IBM NO. 2
10

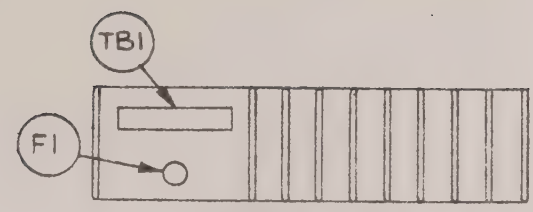


SCHEMATIC FOR TRIGGER AMPLIFIER
SUBASSEMBLY (95 P.C.)

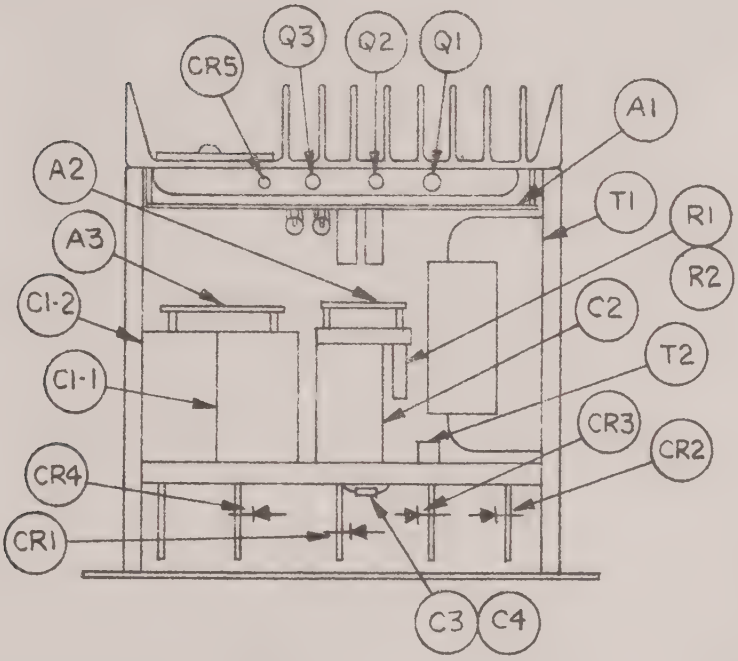
FIG. 5-1B

VARIABLE COMPONENTS					
	C5	R3	R7, R8	R9, R10	Q2
95PC-3	50UF, 15V	5.6, 1/2W	15, 1/2W	680, 2W	2N335A
95PC-6	NOT USED	15, 1/2W	27, 1/2W	NOT USED	2N335A
95PC-7	50UF, 15V	15, 1/2W	27, 1/2W	680, 2W	2N335A
95PC-8	50UF, 15V	5.6, 1/2W	15, 1/2W	1000, 2W	TI-481

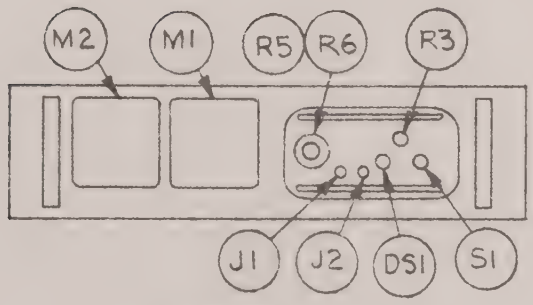
FIG. 5-1C



REAR VIEW



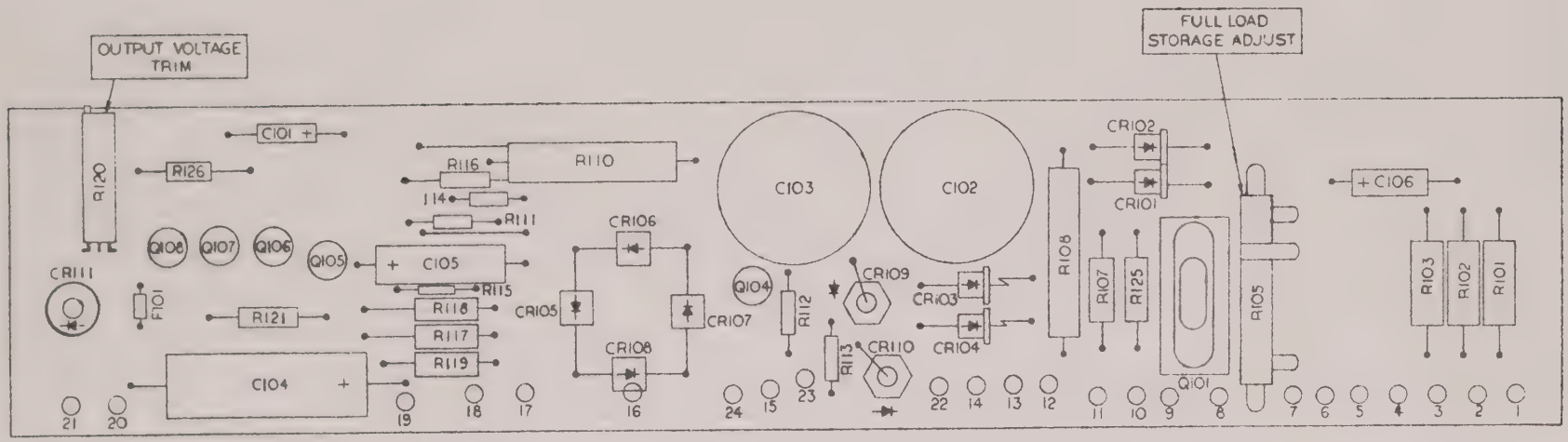
TOP VIEW



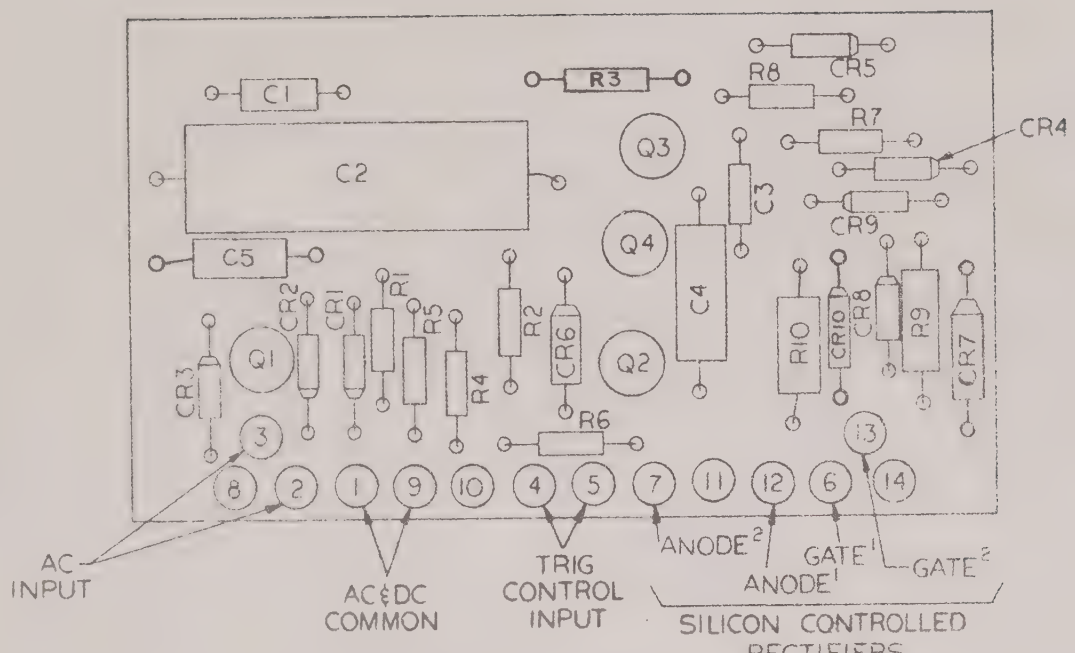
FRONT VIEW

PARTS PLACEMENT - MAJOR COMPONENTS

FIG. 5-2A

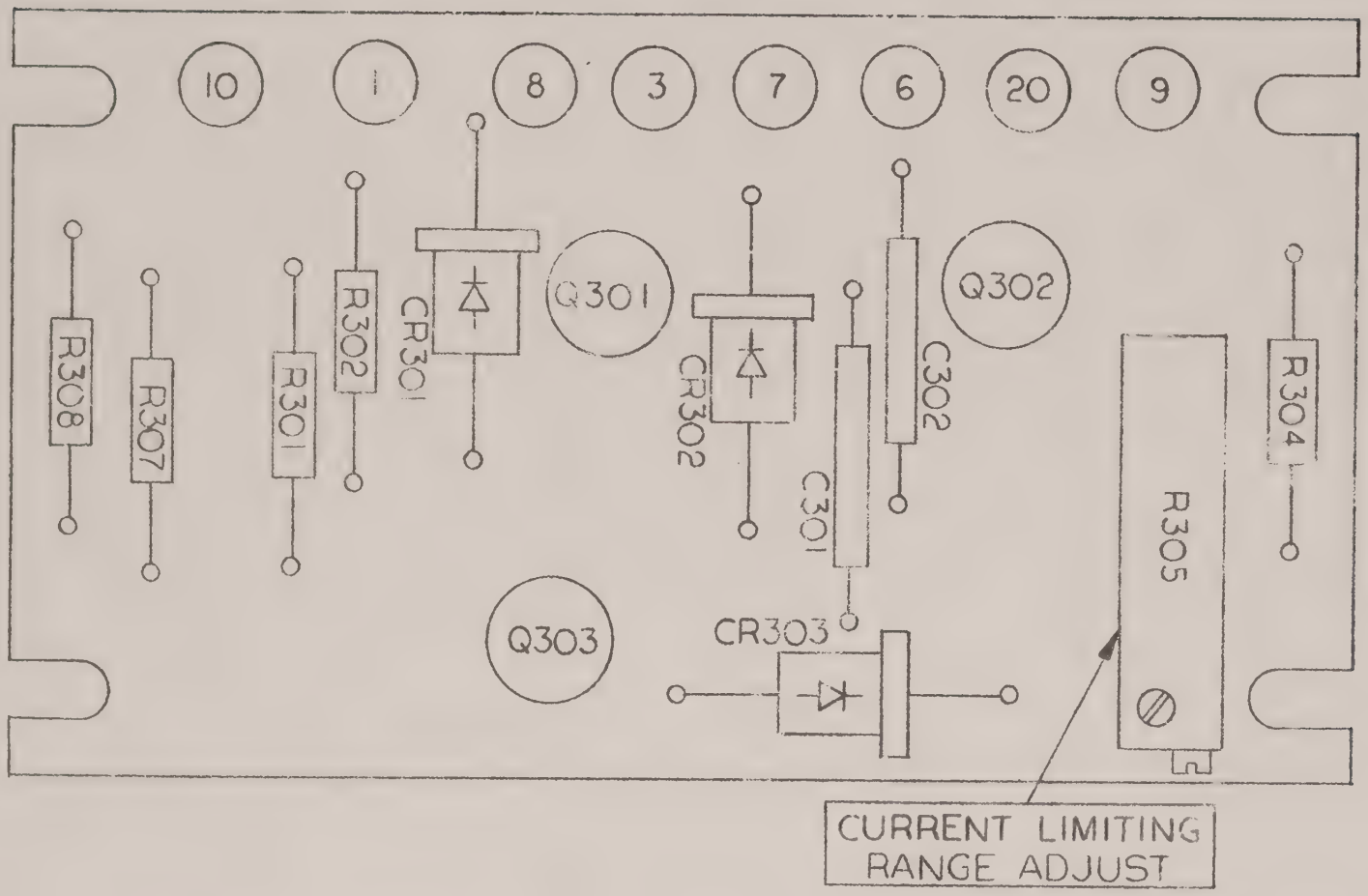


SUBASSEMBLY PARTS PLACEMENT - 51PC-14A
FIG. 5-28



PARTS PLACEMENT
SCR TRIGGER AMP SUBASSEMBLY (95 PC)
FIG. 5-2C

801690



PARTS PLACEMENT FOR
PRINTED CIRCUIT BOARD SUBASSEMBLY(81 PC)

FIG. 5-2D

102749

ABBREVIATIONS USED IN SPARE PARTS LIST

In Description Column: "SA" is used to mean "Same As" and "PO" is used to mean "Part Of". Where these symbols are used, the UNIT QTY, SPARE QTY, UNIT PRICE and NJE PART NO. columns are all blank.

In Value Column: The use of the letter R to indicate a decimal point is illustrated by the following examples: 5.6KΩ is written as 5R60K. 1/2 Watts is written as R500 W. The use of zeroes does not imply a precision to the indicated number of decimal places but is a requirement of the proper handling of the Data Processing Cards from which these spare parts lists are written.

The standard symbols for electrical units are used and usually appear in the columns immediately to the left of the dashed and solid lines in the Value field. In all cases, the symbol Ω is not printed for resistors and is understood. For example: 200Ω is written 200 and 2.7MΩ is written 2R70 M.

In Reference Designation Column: The reference designations are those which interrelate the Spare Parts List, the Schematic Diagrams and the Parts Placement drawings. The symbols are those of MIL - STD 16. Where the reference designation is an "A" (meaning a subassembly) a Spare Parts List bearing the NJE Part Number of that assembly is included in the Spare Parts List section.

Deviations: Where minor deviations are accomplished by modifying a standard unit, a Spare Parts List which only shows the deletions and additions from the enclosed standard Spare Parts List is used.

NJE CORP. KENILWORTH, N.J.

SPARE PARTS LIST

MODEL CR36 8B 81014 PAGE NO.

REFERENCE DESIGNATION	DESCRIPTION VENDOR NAME*	RATINGS VENDOR PART NO.*		NJE PART NO.	QTY. USED	SPARE QTY.	UNIT PRICE
A1	SUBASSY 51PC 14A			81654	01	01	
A2	SUBASSY 81PC 1			81632	01	01	
A3	SUBASSY 95PC 3			81658	01	01	
C1	CAP FXD ELECT	10000UF	50 V	7	02	01	27.00
C2	CAP FXD ELECT	6700UF	50 V	8	01	01	19.20
C3	CAP FXD PAPER	10000PF	400 V	16	02	01	.75
C4	SA C3						
CR1	RECTIFIER CONTROL	25 A	100 V	198	02	02	17.50
CR2	DIODE RECTIFIER 5	12 A		20698	02	02	3.00
CR3	SA CR2						
CR4	SA CR1						
DS1	PILOT LAMP	T3	R250 W	24	01	01	.50
F1	FUSE CARTRIDGE	6R00 A	32 V	29	01	05	.25
J1	CONNECTOR RECEPT	1 PIN	30 A	33	01	01	.80
J2	CONNECTOR RECEPT	1 PIN	30 A	32	01	01	.80
M1	AMMETER DC	10R0 A		38	01	01	22.00
M2	VOLTMETER DC	50R0 V		41	01	01	22.00
Q1	TRANSISTOR PNP 5E	50 W	55 V	161	03	02	7.00
Q2	SA Q1						
Q3	SA Q1						
R1	RES FXD WW	150R00	25 W	81	01	01	1.40
R2	RES FXD WW	750R00	25 W	85	01	01	1.40
R3	RES VAR WW	1R00 K	2 W	150	01	01	2.25
R4	RES VAR WW	5R00 K	10 W	116	01	01	20.00
S1	SWITCH	SPST	15 A	20605	01	01	1.50
T1	TRANSFORMER			22070	01	01	76.75
T2	TRANSFORMER			21301	01	01	10.05
TB1	TERMINAL BOARD	12 TERM	15 A	124	01		1.65
XDS1	LAMPHOLDER	RD CLEAR	125 V	20658	01		1.10
XF1	FUSE HOLDER	30 A	250 V	20631	01		.50
	MISCELLANY						
H8	KNOB DECADE			4563	01		15.00
	KNOB	R250IN	HOLE	21242	01		.65
H1	HANDLE	3R000IN	X1R5IN	2814	02		2.10
	51PC 14A SPARE			81654			
C101	CAP FXD ELECT	25UF	25 V	664	01	01	2.34
C102	CAP FXD ELECT	300UF	150 V	14	02	01	3.00
C103	SA C102						
C104	CAP FXD PAPER	2UF	200 V	18	01	01	3.75
C105	CAP FXD PAPER	R05UF	200 V	15	01	01	.50
C106	CAP FXD ELECT	250UF	3 V	20694	01	01	2.40
CR101	DIODE RECTIFIER 5	750MA	300 V	138	02	02	1.20
CR102	SA CR101						
CR103	SA CR101						

*SPARE PARTS LIST SPECIFYING TYPICAL VENDOR'S NAME AND PART NUMBER IS AVAILABLE ON SPECIAL ORDER ONLY.

1 - When ordering spare parts it is necessary to specify the serial number and model number (available on the warranty label on the rear of the unit) and the NJE Part No. from this spare parts list.
2 - Unit Price shown above is subject to change without prior notice.
3 - NJE Corp. reserves the right to make design improvements on this unit without prior notice.
4 - Spare Quantity shown above is recommended quantity for one year isolated service.

MANUFACTURER'S REPRESENTATIVES

*California, Los Angeles
Ault Associates
931 So. Prairie Avenue
Inglewood, California
OR 8-6144

California, San Francisco
Ault Associates
120 Santa Margarita
Menlo Park, California
DA 6-1760

Canada Montreal
Radionics, Ltd.
8230 Mayrand Street
Montreal, Canada
REgent 9-5517

Canada, Ontario
Radionics, Ltd.
4938 Yonge Street
Willowdale, Ontario
222-3261

Colorado, Denver
Scientific Instrument Company
1435 So. Milwaukee Street
Denver 10, Colorado
AL 5-2777

Florida, Clearwater
W. Ben Wimberley Co., Inc.
532 South Fort Harrison Ave.
Clearwater, Florida
(813) 446-7072

Florida, Orlando
W. Ben Wimberley Co., Inc.
500 Osceola Street
Orlando, Florida
425-3083

*Illinois, Chicago
Ridgway Associates
3759 North Harlem Ave.
Chicago 34, Ill.
282-5929

Indiana, Indianapolis
1224 N. Capitol Avenue
Indianapolis 2, Indiana
MElrose 5-2401

Massachusetts, Boston
Burlingame Associates, Ltd.
7 Wellington Street
Waltham, Mass.
TWinbrook 4-1955

Michigan, Detroit
Ridgway Associates
3384 Twelve Mile Road
Berkley, Michigan
Lincoln 6-3312

Minnesota, Minneapolis
Ridgway Associates
7735 Morgan Avenue, So.
Minneapolis 23, Minnesota
866-3305

Missouri, Kansas City
Lee Mark Associates
4201 W. 86th Street
Shawnee-Mission, Kansas
Niagara 2-3313

Missouri, St. Louis
Lee Mark Associates
2001 Big Bend Blvd.
St. Louis 17, Mo.
Mission 7-1470

New York, Mount Vernon
Burlingame Associates, Ltd.
510 South Fulton Avenue
Mt. Vernon, N. Y.
MOunt Vernon 4-7530

New York, Syracuse
Burlingame Associates, Ltd.
106 Pickard Building
E. Molloy Road, Syracuse, N. Y.
(315) 454-2408

No. Carolina, Burlington
M. J. McDonald Co.
514 Hillcrest Avenue
Burlington, N. Carolina
226-7177

No. Carolina, Winston-Salem
M. J. McDonald Co.
Whippoorwill Drive, Rt. 1
Pfafftown, N. C.
WAbash 4-2182

Ohio, Dayton
Ridgway Associates
3898 Linden Avenue
Dayton 29, Ohio
CLearwater 2-5604

Ohio, Cleveland
Ridgway Associates
5249 Broadview Road
Cleveland 34, Ohio
(216) 749-6626

Penna., Philadelphia
Burlingame Associates, Ltd.
222 Long Lane
Upper Darby, Pa.
JAckson 8-6080

Texas, Dallas
Carey-Wolf Co.
P.O. Box 12425
Ft. Worth, Texas
TA 3-5383(Dallas)

Texas, Ft. Worth
Carey-Wolf Co.
P.O. Box 12425
Ft. Worth, Texas
PE 8-1702

Texas, Houston
Carey-Wolf Co.
P.O. Box 60338
Houston, Texas
OL 4-2114

Washington, Seattle
Ray Johnson Co., Inc.
1011 N.E. 69th Street
Seattle 15, Washington
LA 4-5170

Washington, D. C.
Burlingame Assoc., Ltd.
8218 Wisconsin Ave., N.W.
Washington 14, D. C.
OLiver 4-6400

*Local Service Centers.

Our Warranty:

N J E Corp. warrants each power supply manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replacing any defective parts thereof, except tubes, semi-conductors and fuses. This warranty is effective for five years after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and which upon our examination is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started. Written permission must be obtained from the factory, before a supply may be returned for examination.

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